A Systematic Review of Bright Light Therapy for Eating Disorders

Marshall T. Beauchamp, MS,[a] and Jennifer D. Lundgren, PhD[a,*]

ABSTRACT

Objective: Bright light therapy is a noninvasive biological intervention for disorders with nonnormative circadian features. Eating disorders, particularly those with binge-eating and night-eating features, have documented nonnormative circadian eating and mood patterns, suggesting that bright light therapy may be an efficacious stand-alone or adjunctive intervention. The purpose of this systematic literature review, using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, was (1) to evaluate the state of the empirical treatment outcome literature on bright light therapy for eating disorders and (2) to explore the timing of eating behavior, mood, and sleep-related symptom change so as to understand potential mechanisms of bright light therapy action in the context of eating disorder treatment.

Data Sources: A comprehensive literature search using PsycInfo and PubMed/MEDLINE was conducted in April 2016 with no date restrictions to identify studies published using bright light therapy as a treatment for eating disorders. Keywords included combinations of terms describing disordered eating (*eating disorder*, *anorexia nervosa*, *bulimia nervosa*, *binge eating*, *binge*, *eating behavior*, *eating*, and *night eating*) and the use of bright light therapy (*bright light therapy*, *light therapy*, *phototherapy*). After excluding duplicates, 34 articles were reviewed for inclusion.

Study Selection and Data Extraction: 14 published studies of bright light therapy for eating disorders met inclusion criteria (included participants with an eating disorder/disordered-eating behaviors; presented as a case study, case series, open-label clinical trial, or randomized/nonrandomized controlled trial; written in English; and published and available by the time of manuscript review).

Results: Results suggest that bright light therapy is potentially effective at improving both disordered-eating behavior and mood acutely, although the timing of symptom response and the duration of treatment effects remain unknown.

Conclusions: Future research should systematically control for placebo response, assess symptom change frequently and across a broad range of systems, and evaluate the longer-term efficacy of bright light therapy for eating disorders.

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[a]Department of Psychology, University of Missouri–Kansas City, Kansas City

**Corresponding author:* Jennifer D. Lundgren, PhD, Department of Psychology, University of Missouri–Kansas City, 5030 Cherry St, Kansas City, Missouri, 64116 (lundgrenj@umkc.edu).

Circadian rhythm, or the variation in physiology and behavior that corresponds approximately to a 24-hour cycle,[1] is disrupted in a variety of behavioral health conditions including mood disorders,[2,3] sleep-wake disorders,[4,5] and eating disorders.[6–8] Circadian rhythm is regulated by biological clocks located both centrally, in the suprachiasmatic nuclei of the anterior hypothalamus, and peripherally in the organs such as the liver, gut, pancreas, fat, and muscle.[9] The central circadian clock is synchronized (entrained) by cues, primarily light exposure and food intake. Other types of stimuli, however, can serve as synchronizing agents in the cellular circadian clocks throughout the body, including temperature, exercise, and even social cues.[1,10]

The eating disorder with the most prominent circadian dyssynchrony is night eating syndrome,[11] characterized by a circadian delay of food intake manifested by evening hyperphagia and/or nocturnal awakening and ingestion of food.[7,12] Neuroendocrine hormones associated with ingestive behavior, including leptin and insulin, have been found to mirror the phase-delayed food-intake pattern of individuals diagnosed with night eating syndrome.[6] In this same study,[6] ghrelin was phase advanced nearly 5 hours and glucose circadian rhythm was inverted. The authors[6] cautioned that cause and effect between the nonnormative hormonal patterns and the circadian-delayed eating patterns cannot be established in their study, and it is plausible that eating behavior was entraining physiology in their sample. In addition to the prominent feature of circadian-delayed ingestive behavior and associated nonnormative hormonal circadian phase shifts found in persons with night eating syndrome, there is evidence of a unique circadian pattern of mood that worsens in the latter half of the day in many individuals diagnosed with night eating syndrome.[7] This circadian mood pattern is reflected in the research diagnostic criterion that mood disturbance worsens in the evening.[11] Although there is no evidence of a circadian phase delay or advance in the sleep patterns of individuals diagnosed with night eating syndrome, sleep architecture and quality is disrupted, particularly in people who regularly wake at night and consume food.[13] Sleep disruption is an important aspect of circadian rhythm in individuals with night eating syndrome because light is involved in the entrainment of the central circadian clock.

Night eating syndrome is not the only eating disorder to display nonnormative circadian features. For example, Lavender and colleagues[14] found that dietary restriction among individuals diagnosed with anorexia nervosa is more likely to occur in the first half of the day and that binge and purge episodes are more likely to occur in the evening. Mood disturbance that co-occurs with eating disorders also displays circadian features (eg, mood that worsens throughout the day)[8] or seasonal worsening of mood.[15] Ecological momentary assessment demonstrates that many individuals who struggle with binge eating experience the highest frequency of binge eating on days characterized by a circadian pattern of worsening

Clinical Points

- Preliminary evidence suggests that bright light therapy can improve eating disorder symptoms and mood during the active intervention for those without contraindications.
- Exposure to morning light at 10,000 lux for at least 30 minutes is common in the treatment outcome literature.
- Patient treatment outcomes should be evaluated across a variety of symptom domains.

affect throughout the day.[16] Although the circadian timing of sleep does not appear to have phase advances or delays, disordered-eating behaviors are often associated with disruptions in the sleep-wake cycle.[17] Binge-eating behavior has been associated with lifetime histories of sleep disturbance,[18] with some evidence that disordered-eating behaviors precede difficulty initiating and maintaining sleep over time in young adults.[19] As noted previously, the fact that sleep is so frequently disrupted in eating disorders is important from the perspective of circadian rhythm health because the sleep-wake and light-dark cycles are important central circadian rhythm synchronizers.[1]

Because light exposure is a central circadian synchronizer, bright light therapy is increasingly being used as a noninvasive biological intervention to treat disorders with circadian rhythm disruption. Administration of bright light therapy generally involves daily exposure to a specialized fluorescent light box designed to give off light at a much brighter intensity to that of indoor lighting, typically around 5,000 to 10,000 lux, for a minimum of 1 week in order to see therapeutic effects.[20] Lux is a unit of light intensity measured at a specific distance from a light source (differing from lumens, which is the total light output measured at the source and not taking into account area or spread of the light). Examples of common lux ranges encountered include 100–500 lux (residential indoor lighting), 500–700 lux (well-lit office buildings), 10,000 lux (sunrise on a clear spring day), and 100,000 lux (noontime on a summer day).[21] Mårtensson and colleagues[22] documented significant variability in the length of bright light therapy among treatment outcome studies for both seasonal and nonseasonal depression (range, 1 week–6 weeks). The nature of the circadian disruption (eg, jet lag vs seasonal affective disorder) dictates the timing of bright light therapy exposure, but early morning exposure is more effective than evening exposure for mood disorders.[23] The hypothesized mechanisms of action of bright light therapy, particularly for seasonal affective disorder, is the central realignment of circadian phase as the result of ocular light exposure, as well as increased alertness and arousal.[20,24]

Bright light therapy has been evaluated as an intervention for the treatment of disordered-eating behavior, particularly disorders involving binge-eating and night-eating behavior. To our knowledge, no systematic review has been conducted to summarize the state of the literature or explore patterns of treatment outcome. Therefore, the purpose of this review, using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines,[25] is (1) to evaluate the state of the empirical treatment outcome literature on bright light therapy for eating disorders, while being inclusive of multiple intervention methodologies and eating-disordered populations and (2) to explore the timing of eating behavior, mood, and sleep-related symptom change with bright light therapy so as to understand better potential mechanisms of bright light therapy action in the context of eating disorder treatment. Notably, we have focused our review on the specific behaviors of eating, mood, and sleep because of the well-established relationship between mood and eating behavior across eating disorders[6,7] and the substantial empirical support for bright light therapy as an intervention for mood disorders, particularly those with a seasonal pattern.[22] Additionally, sleep is an important outcome given the documented sleep disturbances associated with eating disorders[13,18,19] and the role of the light-dark (sleep-wake) cycle in maintaining circadian rhythm. It is important to critically evaluate the state of the literature in order to inform future treatment outcome research using bright light therapy, particularly as the role of circadian rhythm disruption on behavioral health is increasingly being recognized.[26]

METHODS

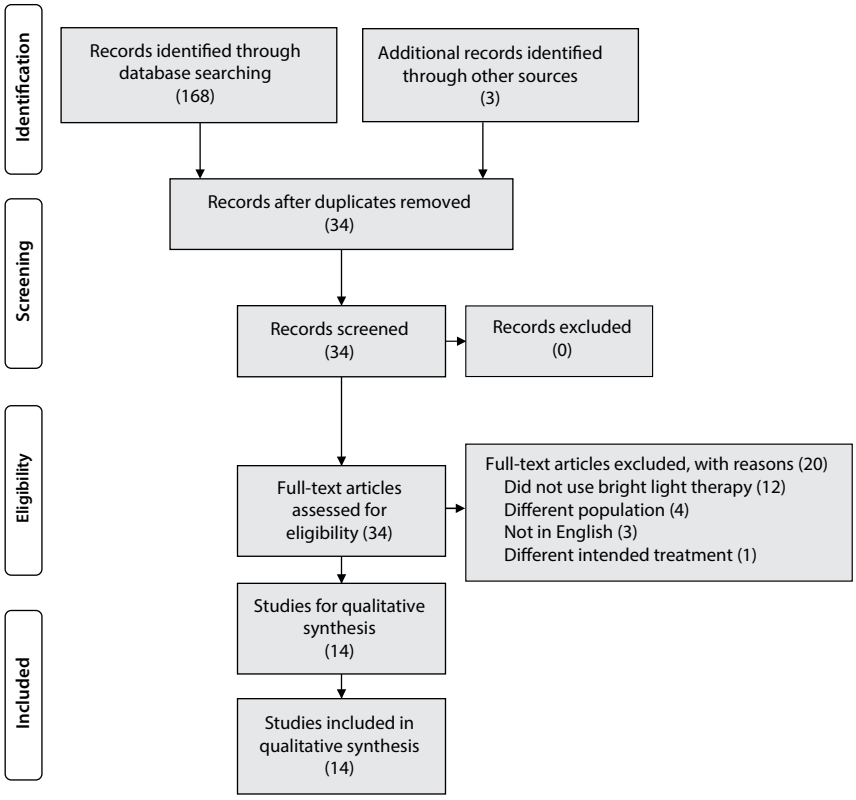
Literature Search

A comprehensive literature search using PsycInfo and PubMed/MEDLINE was conducted to identify published studies indicating the use of bright light therapy as a treatment for eating disorders. The search was performed in April 2016 with no date restrictions using combinations of keywords describing disordered eating (*eating disorder*, *anorexia nervosa*, *bulimia nervosa*, *binge eating*, *binge*, *eating behavior*, *eating*, and *night eating*) and the use of bright light therapy (*bright light therapy*, *light therapy*, *phototherapy*). We searched the reference lists of other previously published studies to find additional articles. After excluding duplicates, the search resulted in 33 studies. During the manuscript review process, 1 additional study was published and included, yielding a total of 34 articles to be reviewed

Inclusion and Systematic Review Methods

Each of the 34 articles was screened by the first author (M.T.B.) using review inclusion criteria. Studies were deemed eligible if they (1) included participants diagnosed with an eating disorder or disordered-eating behaviors (eg, subthreshold eating disorder diagnosis, weight restricting, binge-purge episodes, compensatory behaviors, night eating), regardless of comorbid diagnoses (eg, mood disorders); (2) were presented as a case study, case series, open-label clinical trial, or a randomized or nonrandomized controlled clinical trial; (3) were reported in English; and (4) were published and available as of April 1, 2016. Additionally, articles were included if bright light therapy was the primary treatment or if it was adjunctive to another primary intervention, as long as the primary intervention did not change or was controlled for the duration of the

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Flowchart of Study Selection and Rationale for Exclusion



bright light therapy. Because of the relatively low number of articles found, there were no methods used to assess risk of bias of individual studies.

For all included studies, the first author (M.T.B.) systematically reviewed the report and documented (1) the study design (eg, case study, case series, open-label clinical trial, or randomized/nonrandomized clinical trial; status of bright light therapy as a primary treatment) and methodology: bright light therapy intensity of light, session length and times per day, and duration of treatment; (2) the study and participant characteristics: participant mean age, gender composition, study sample size, diagnoses (eg, eating disorder and any comorbidity with seasonal affective disorder or major depression); and (3) outcome assessment and results of the study: measures used and follow-up outcomes if present. For studies that included assessments across multiple time points, the timing of change in eating disorder symptoms, mood, and sleep was documented in order to evaluate the timing of symptom change in relation to one another. The second author (J.D.L.) verified this process.

RESULTS

Of the 34 articles identified, 14 studies[27–40] were eligible for inclusion in the review. Details about each of these 14 studies can be found in Table 1.

The remaining 20 articles were excluded on the basis of the following reasons: 12 studies did not actually use bright light therapy for disordered-eating behavior or were reports on treatment approaches for eating disorders; 3 studies used bright light therapy in a population with seasonal affective disorder, but recorded eating and dietary preferences; 3 studies were not reported in English; 1 study used bright light therapy in a population with Alzheimer's disease; and 1 study used bright light therapy for weight reduction in an obese population. A PRISMA flow diagram[25] depicting the phases of article identification, inclusion, and exclusion can be found in Figure 1.

Study Methodology and Characteristics

Design. As Table 1 illustrates, case studies (those following 1 participant over time) were the most frequently used study design (5 studies[30,36–38,40]). Three of those used bright light therapy in conjunction with pharmacotherapy. Randomized controlled trials (in which participants were randomly assigned to different groups) were the next most frequently used design (4 studies[28,31–33]). Three of those compared bright light therapy to a dim red light placebo condition; 1 compared bright light therapy in conjunction with cognitive-behavioral therapy (CBT) to CBT alone. These randomized controlled trials varied in their methodological designs (eg, crossover vs parallel, double-blind vs single-blind). The remaining 5 studies were open-label clinical trials (in which

Table 1. Study Characteristics and Results by Eating Disorder

Diagnosis	Author	Study Design	Intensity and Duration of Treatment	Participant Characteristics[a]	Outcome Measures (subscales)	Primary Results	Follow-Up
Anorexia nervosa–restricting	Daansen and Haffmans[27]	Case series	10,000 lux 5 d 30 min/d	N = 6 Age: 34.2 (7.9) Female: 100%	EDI-II (drive for thinness, bulimia, body dissatisfaction, interoceptive awareness), BDI-II, SCL-90 (sleeping disorder)	Qualitative analyses: "slight improvement" at posttreatment on all included EDI-II subscales, depression scores on BDI-II, and sleep scores on SCL-90	Twelve weeks later, eating pathology, depression, and sleep continued to show slight improvements, but benefits of light were partially lost
Anorexia nervosa–restricting	Janas-Kozik et al[28]	Randomized controlled trial[b]	10,000 lux 6 wk 30 min/d	N = 24 Age: 17.4 (1.2) Female: 100%	BMI, HDRS	No significant differences in BMI between groups at posttreatment, although the bright light therapy group achieved a significant increase in BMI sooner than the control group; significantly greater and faster reduction on HDRS scores at posttreatment for bright light therapy group compared to control	NA
Anorexia nervosa, bulimia nervosa–no specified subtype	Yamamotová et al[29]	Nonrandomized controlled trial	5,000 lux 1 wk 60 min/d	N = 25 Age: 23.9 (4.3) Female: 100%	Hunger and appetite diaries, HDRS	Hunger rhythms were significantly correlated with body temperature rhythms at posttreatment but only when analyses for those with anorexia nervosa and bulimia nervosa were combined	NA
Bulimia nervosa–purging	Schwitzer et al[30]	Case study[c]	2,500 lux 1 wk 120 min, 2 times/d	N = 1 Age: 24 Female	Binge/purge frequency, observed mood	Bright light therapy was combined with fluoxetine 20 mg daily; decreased binge/purge frequency (1–3 daily to 1 during the treatment week) and improved mood were observed	NA
Bulimia nervosa–purging	Lam et al[31]	Randomized controlled trial	10,000/500 lux 2 wk 30 min/d	N = 17 Age: 31.6 (6.5) Female: 100%	Binge/purge frequency, visual analog bulimia intensity, SIGH-SAD, BDI	For all outcome variables, bright light therapy group showed significant improvements when compared to baseline and the control group; no order effects seen	NA
Bulimia nervosa–purging	Blouin et al[32]	Randomized controlled trial	2,500/500 lux 1 wk 120 min/d	N = 18 Age: 27.9 (8.0) Female: 100%	Binge/purge frequency, BSCL, SIGH-SAD, BDI, POMS (depression)	No significant difference in binge/purge frequency or scores on BSCL between groups at posttreatment; significant decrease in depression scores at posttreatment on all measures in bright light therapy group; no effect in control group	One week later, levels of depression on all measures returned to pretreatment levels
Bulimia nervosa–purging	Braun et al[33]	Randomized controlled trial	10,000/50 lux 3 wk 30 min/d	N = 34 Age: 30.5 (7.9) Female: 100%	Binge/purge frequency, SIGH-SAD, BDI, SPAQ	Significant greater reductions in binge frequency, but not purge frequency, during treatment in bright light therapy group; significant decrease in depression scores on all measures over time but no differences between groups	Two weeks later, binge-eating episode reductions from bright light therapy were sustained, but no significant differences between groups

(continued)

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Table 1 (continued). Study Characteristics and Results by Eating Disorder

Diagnosis	Author	Study Design	Intensity and Duration of Treatment	Participant Characteristics[a]	Outcome Measures (subscales)	Primary Results	Follow-Up
Bulimia nervosa–purging	Lam et al[34]	Open-label clinical trial	10,000 lux 4 wk 30–60 min/d	N = 22 Age: 30.2 (5.5) Female: 100%	Binge/purge frequency, SIGH-SAD, BDI	Significant improvements on all outcome variables at posttreatment	NA
Bulimia nervosa–purging	De Young et al[35]	Case series (ABA design)	10,000 lux 2 wk (active bright light therapy) 30 min/d	N = 9 Age: 23.6 (5.2) Female: 100%	Binge/purge frequency, CHEDS, STICSA, CESD-R, PANAS-X	Significant improvements in binge eating and vomiting, independent of negative affect; significant improvements in fatigue	Specific follow-up analyses not reported; mean scores on CHEDS subscales and the probability of binge eating during the return to baseline phase suggest that improvements were not maintained
Bulimia nervosa–nonpurging	Hilger et al[36]	Case study[c]	10,000 lux 4 wk 45 min, 2 times/d	N = 1 Age: 34 Female	Observed appetite, hyperphagia, and carbohydrate craving, HDRS, HDRS-SUPPL	No effect of bright light therapy or bright light therapy combined with sertraline 150 mg/d	NA
Night eating syndrome	Friedman et al[37]	Case study	10,000 lux 2 wk 30 min/d	N = 1 Age: 51 Female	Food record for night eating syndrome criteria, SIGH-SAD, BDI	As posttreatment, no longer met criteria for night eating syndrome; significant reduction in depression scores on all measures	Four weeks later, NESS symptoms, but not depression, returned; symptoms remitted after 12 days of additional bright light therapy
Night eating syndrome	Friedman et al[38]	Case study	10,000 lux 2 wk 30 min/d	N = 1 Age: 46 Male	Food record for night eating syndrome criteria, SIGH-SAD, HAD	At posttreatment, no longer met criteria for night eating syndrome; significant reduction in depression scores on all measures	NA
Night eating syndrome	McCune and Lundgren[39]	Open-label clinical trial	10,000 lux 2 wk 60 min/d	N = 15 Age: 42.2 (15.0) Female: 93.3%	NESS, daily nocturnal food logs, BDI-II, daily visual analog mood and anxiety, ISI	Significant improvements on all outcome variables at posttreatment	NA
Eating disorder not otherwise specified	Ash et al[40]	Case study	10,000 lux 4 d–4 wk 30 min/d	N = 1 Age: 17 y Female	EAT, observed eating difficulties, SIGH-SAD, BDI, observed mood	After 4 days, observed dietary intake and mood improved "considerably"	Four weeks later, dietary intake, EAT, and all depression measure score improvements from posttreatment were sustained while participant used light box; when discontinued, all symptoms remitted

[a]Age is presented as mean (SD), y unless only 1 patient is reported.
[b]Study compared bright light therapy combined with CBT to a CBT-only control group.
[c]Study combined bright light therapy with psychopharmacologic drug.
Abbreviations: ABA = case series design involving a baseline phase, active intervention phase, and return to baseline phase; BDI = Beck Depression Inventory; BMI = body mass index; BSCL = Bulimia Symptom Checklist; CBT = cognitive-behavioral therapy; CESD-R = Center for Epidemiologic Studies Depression Scale–Revised; CHEDS = Change in Eating Disorder Symptoms scale; EAT = Eating Attitudes Test; EDI = Eating Disorder Inventory; HAD = Hospital Anxiety and Depression scale; HDRS = Hamilton Depression Rating Scale; HDRS-SUPPL = Hamilton Depression Rating Scale–Supplemental; ISI = Insomnia Severity Index; NA = not applicable; NESS = Night Eating Symptom Scale; PANAS-X = Positive and Negative Affect Schedule–Expanded Form; POMS = Profile of Mood State; SCL-90 = Symptom Checklist–90; SIGH-SAD = Structured Interview Guide for the Hamilton Depression Rating Scale–Seasonal Affective Disorder version; SPAQ = Seasonal Pattern Assessment Questionnaire; STICSA = State-Trait Inventory for Cognitive and Somatic Anxiety.

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all participants received bright light therapy, 2 studies[34,39]), a case series (similar to the case study design but following multiple participants, 2 studies[27,35]), or a nonrandomized controlled trial against healthy participants (1 study[29]). Five studies[27,32,33,37,40] included a follow-up period, which is the interval between the last bright light therapy session and the outcome measure, that ranged from 1-week to 12-week periods.

Light box methodology. Studies varied in their methodological use of light box treatment. The majority (11 studies) used 10,000 lux as their standard light intensity for active treatment, with 1 study[29] using 5,000 lux and 2 studies[30,32] using 2,500 lux. When dim red light was used as a control or comparison condition, 2 studies[31,32] used 500 lux as the intensity and 1 study[33] used 50 lux.

As seen in Table 1, session length was quite variable (30 minutes once a day to 120 minutes twice a day). However, the majority (8 studies[27,28,31,33,35,37,38,40]) reported a treatment duration of 30 minutes once a day. Duration of active treatment varied (4 days to 6 weeks). The 2 most common active treatment duration lengths were 2 weeks (5 studies[31,35,37–39]) and 1 week (3 studies[29,30,32]), with all other studies using unique treatment durations. Time of day for light box usage varied, with most study protocols prescribing light box exposure during the morning (11 studies[27–29,31,33–35,37–40]; either generally during the morning hours or at an exact time), although the others prescribed light box usage in the late afternoon and early evening (from 5:00–7:00 PM),[32] both morning and evening (7:00–9:00 AM and 6:00–8:00 PM),[30] or not specified.[36]

Participant characteristics and diagnoses. Excluding case studies with 1 participant (5 studies[30,36,37,38,40]), the average number of participants in each of the 9 remaining studies was 18.89 (SD = 8.55), with a range of 6–34 participants. The mean age for participants across all studies (n = 175 individuals) was 30.96 years old (SD = 10.06). The majority of participants were female (98.9%, n = 173), and the vast majority of studies did not report participant ethnicity. Almost half of all participants (49.3%, n = 82 individuals) had a comorbid mood diagnosis.

All 14 studies included participants with full-threshold eating disorder diagnosis or disordered-eating behavior. Of the included studies, 2[27,28] included individuals with anorexia nervosa (restricting subtype), 6[30–35] included individuals with bulimia nervosa (purging type), 1[36] included an individual with bulimia nervosa (nonpurging type), 3[37–39] included individuals with night eating syndrome, 1[40] included an individual with a diagnosis of eating disorder not otherwise specified (*DSM-III-R*[41] criteria) used at the time of the study, and 1[29] included a mix of individuals with either anorexia nervosa or bulimia nervosa (subtypes were not specified). See Table 1 for the listing of eating disorder diagnosis by study.

Assessments. The full list of measures used in the studies can be found in Table 1. Each study assessed eating pathology and mood. Food diaries and binge/purge logs were the most frequently used assessments for disordered eating, including the number of binge and purge episodes (10 studies[29–35,37–39]). Three studies used a self-report symptom assessment to measure disordered-eating behavior (Change in Eating Disorder Symptoms Scale,[35] Eating Disorder Inventory-II [EDI-II],[42] or Bulimia Symptoms Checklist[43]). The original Beck Depression Inventory[44] and the Structured Interview Guide for the Hamilton Depression Rating Scale, Seasonal Affective Version[45] were the most frequently used assessments of mood. Sleep/wake diaries were used to assess sleep in 4 studies, although only 2[27,39] reported sleep as an outcome variable; they used the Symptom Checklist-90 (SCL-90)[46] and the Insomnia Severity Index (ISI),[47] respectively, as their measures for sleep.

Summary of Results by Eating Disorder Diagnosis

Anorexia nervosa. Two studies[27,28] examined participants with anorexia nervosa–restricting subtype, with 1 additional study[29] including participants with anorexia nervosa, although subtype was not specified. Daansen and Haffmans[27] reported that after bright light therapy and at a 12-week follow-up, they found "slight improvement" on core eating pathology as assessed by the drive for thinness, bulimia, body dissatisfaction, and interoceptive awareness subscales on the EDI-II. However, due to small sample size, these analyses were examined qualitatively. Janas-Kozik and colleagues[28] used body mass index (BMI) as a proxy for eating behavior and found no significant differences at posttreatment for the bright light therapy + CBT group compared to a CBT-only control. They reported, however, that the group with bright light therapy achieved a significant increase in BMI compared to baseline much sooner than the control group (3 weeks compared to 6 weeks). Yamamotová and colleagues[29] found that after bright light therapy, hunger rhythms were significantly correlated with body temperature rhythms. They stipulated, however, that this effect was evident only after participants with anorexia nervosa were pooled with those with bulimia nervosa.[29]

All 3 studies reported significant (or in the case of Daansen and Haffmans,[27] moderate qualitative) reductions in depressive symptoms at posttreatment. Janas-Kozik et al[28] found a significantly greater reduction in symptoms, faster reduction of symptoms (third week compared to fourth week), and lower intensity of symptoms at posttreatment from baseline for the bright light therapy + CBT group when compared to the control. The Daansen and Haffmans[27] study was the only one to include a follow-up for this population, and they reported that "benefits were partly lost" after 3 months.[(p295)] Daansen and Haffmans[27] reported having slight improvement from average to below average scores for sleep on the SCL-90 at both posttreatment and follow-up. They stated that this was verified with reports from the participants' sleep diaries.

Bulimia nervosa. Seven studies[30–36] examined participants with bulimia nervosa (6 with bulimia nervosa, purging subtype, and 1 with bulimia nervosa, nonpurging subtype). Results for disordered-eating behavior symptoms were mixed. Four studies[30,31,34,35] found significant

decreases in binge-eating episodes and purge frequency at posttreatment. Of the remaining studies, both Blouin and colleagues[32] and Hilger and colleagues[36] found no effect of bright light therapy on binge eating or purge frequency. Conversely, Braun and colleagues[33] found significantly greater reductions in binge-eating episodes in the bright light therapy group during treatment compared to control but no effects on purge frequency. When assessing disordered-eating symptoms at a 2-week follow-up, Braun et al[33] reported that binge-eating episode reductions were sustained, but there were no significant differences between groups.

All but 1 study[36] reported significant reductions in depressive symptoms or negative affect. Braun and colleagues,[33] however, reported that depressive symptoms decreased for both the bright light therapy and dim red light control groups over time, and there were no significant differences between groups. Blouin and colleagues[32] also reported that depressive symptoms returned to pretreatment levels at a 1-week follow up. De Young and colleagues[35] noted that fatigue was the only specific facet of negative affect to improve with bright light therapy in their sample.

The Hilger et al[36] case study was the only article in this review to report no effects on both eating pathology and mood with either bright light therapy or bright light therapy in addition to sertraline 150 mg. Symptom reduction was eventually found after administering reboxetine 8 mg per day for 2 weeks. While this study[36] used 4 weeks of bright light therapy twice daily for 45 minutes, there was no specification on prescribed time of day (morning, evening, or a specific time) for treatment administration.

Night eating syndrome. Three studies[37–39] examined participants with night eating syndrome. All 3 studies found significant reductions in night eating syndrome symptoms (eg, morning anorexia, evening hyperphagia, awakenings during the nighttime that include snacking in order to restore sleep), with both case studies[37,38] reporting that the participant no longer met criteria for night eating syndrome, although specific symptom reductions or presence of any remaining subthreshold symptoms were not reported in these studies. In the case of Friedman and colleagues,[37] at a 4-week follow-up, the participant's night eating syndrome symptoms returned but remitted after an additional 12 days of bright light therapy. No specifics on symptoms were reported.

All 3 studies[37–39] also reported significant reductions in depressive symptoms. As mentioned previously, in the Friedman et al[37] study, the participant's night eating syndrome symptoms returned after 4 weeks. However, depressive symptoms remained in remission.

As stated previously, while other articles assessed for sleep, only 2 included sleep as outcome variables. For those with night eating syndrome, the McCune and Lundgren[39] study assessed for sleep as an outcome measure. Decreased ISI scores reflected significant improvements in sleep at posttreatment.

Other. One study[40] included a participant with eating disorder not otherwise specified (presented with *DSM-III-R* symptoms of anorexia nervosa but did not meet the criteria of low body weight). This study found that after 4 days of bright light therapy in an inpatient setting, the participant's eating "improved considerably" and her dietary intake continually improved after 1 month of outpatient light box usage. However, the authors[40] report that after discontinuing bright light therapy for a week, she was "unable to maintain adequate dietary intake."[(p96)] The participant was administered bright light therapy immediately, her dietary intake was re-established, and bright light therapy was subsequently used over time as a prophylactic against further seasonal development of symptoms.[40] Her depressive symptoms followed a similar pattern to her disordered-eating behaviors and were likewise as affected by the presence and absence of bright light therapy.

Order of symptom change. Only 1[32] of the 14 studies presented enough assessment data to examine the order of symptom change. Blouin and colleagues[32] collected daily Profile of Mood State assessments and binge behavior diaries, allowing for an analysis of the covariance between depressed mood and disordered-eating behavior. They found that depressive symptoms assessed by the Beck Depression Inventory and Hamilton Depression Rating Scale significantly decreased after exposure to bright light therapy, but this was not seen in the dim red light control group. They also saw that the depressive symptoms returned to baseline levels after the withdrawal of bright light therapy at the 1-week follow-up. They saw a similar trend in the daily Profile of Mood State ratings for depression but noted that the group × time interaction was not significant. According to the daily binge diaries, the authors[32] found no effect of group or time on binge/purge frequencies, but they noted a reduction of binge frequency over the last 2 days in the intervention group during the bright light therapy period, which was not seen at any other time or in the control group. This reduction, however, was not statistically significant. On the basis of these data, it is difficult to conclude whether decreases in binge episodes were secondary to improvement in depressive symptoms or vice versa. De Young and colleagues[35] collected daily eating behavior and affect assessments but did not report on the order of symptom change across time. Their analyses did demonstrate that binge-eating frequency improved independent of changes in affect.

DISCUSSION

The purpose of this review was 2-fold: (1) to summarize the current state of the literature of bright light therapy with regard to its effect among individuals diagnosed with eating disorders and (2) to explore the relatively sparse outcome data for clues about potential mechanisms of symptom change, particularly in relation to eating behavior, mood, and sleep. While we were able to present a thorough review of the treatment outcome literature, our goal of understanding the relationship of mood, sleep, and eating behavior symptom change in relation to one another was not achieved due to

Table 2. Assessment Domains for Future Studies of Bright Light Therapy for Eating Disorders

Symptom Domain or System	Assessments
Eating behavior	Daily food recall or diary to examine 24-hour feeding rhythms Ecological momentary assessment of eating behavior Laboratory feeding study to objectively assess quantity and quality of food intake and feeding rhythms Self-report eating behavior and eating disorder symptom inventories Structured clinical interviews (eg, Eating Disorder Examination)
Mood	Daily mood ratings Ecological momentary assessment of mood facets Self-report symptom inventories Clinician-rated inventories (eg, Hamilton Depression Rating Scale)
Sleep	Daily sleep diary Self-report sleep quality and quantity inventories Actigraphy to assess sleep quality and quantity Polysomnography to assess sleep architecture, duration, and quality, as well as sleep disorders
Neuroendocrine	The 24-hour circulating levels of neuroendocrine hormones involved in energy intake and sleep, including ghrelin, leptin, glucose, insulin, melatonin, thyroid-stimulating hormone, and cortisol Dim light melatonin onset assessment for assessing phase shifts in melatonin
Neural	fMRI neural response to food cue paradigms (eg, morning vs evening food cue reactivity) fMRI neural response while decision-making paradigms (eg, neural response to immediate, but small reward vs delayed, but larger reward); comparison of neural responses in the morning vs evening to examine circadian changes in self-regulation and impulsivity

Abbreviation: fMRI = functional magnetic resonance imaging.

the dearth of empirical data. Nevertheless, in order to further the state of the literature, we offer our suggestions for future research in the use of bright light therapy for eating disorders to include designs capable of collecting sufficient and necessary data to clarify the resulting mechanisms of action.

Overall, the majority of studies that have examined bright light therapy for disordered eating have demonstrated significant improvements in both depressed mood and eating pathology for the duration of the treatment period, with only a select few studies exhibiting null results in 1 or both of these primary outcomes. These improvements were found regardless of the type of eating disorder present. Sleep, unfortunately, was rarely assessed. Study design, light box methodology, and treatment duration varied among studies, with the majority being case studies utilizing 10,000 lux as the active treatment dose and using the light in the morning for at least 30 minutes daily for 2 weeks.

These findings are consistent with other studies highlighting the potential use of bright light therapy for disordered eating.[48,49] Aigner and colleagues[48] briefly noted the outcomes of the Lam et al[31] and Braun et al[33] studies in their report on pharmacologic interventions for eating disorders. Krysta and colleagues[49] included the results from 6 studies, as well as a discussion on the overlapping role of depression and disordered eating, in their review of treatments for depression in adolescent populations. The current report, however, is the first to systematically review the use of bright light therapy on all forms of disordered-eating behavior. Furthermore, this report also included uncontrolled studies and case studies to provide the only comprehensive review across all ages in the present literature. Importantly, because the studies included in this review varied significantly in methodological quality, the results should be interpreted with significant caution.

Authors have continually suggested that bright light therapy is a potential stand-alone or adjunctive intervention for individuals with disordered eating, especially those with a seasonal component to their symptoms. Relatively few studies, however, are well controlled, and researchers have not attempted to examine the mechanisms of symptom change when using bright light therapy in populations with disordered eating (ie, Why is bright light therapy effective in this population? Is it due to improvement in mood or sleep or is there a mechanism specific to the regulation of food intake?). We suggest that future studies include designs and assessment methods capable of examining these specific parameters.

Table 2 provides a list of suggested assessment techniques across a range of behavioral and physiologic domains relevant to disordered-eating behavior. It is important to assess changes across multiple domains (eg, eating behavior, hunger and satiety hormones, and neural response to food cues) to evaluate potential mechanisms of action in bright light therapy for disordered eating. The inclusion of a dim red light control group via a randomized controlled trial or other similar design would also benefit the literature by controlling for placebo effects and the improvement of depressive symptoms spontaneously over time.

Alongside these suggestions, we also propose that future studies explore an alternative conceptualization of bright light therapy on disordered eating in light of the data on circadian rhythm and sleep disruption in such disorders. Previous studies[29,31] have sought to understand the effect of bright light therapy on disordered eating through the framework of its use in seasonal affective disorder (ie, improvements in mood may lead to improvements in binge/purge episodes, restrictive eating, etc). These studies[29,31] suggest that symptoms of disordered eating, as well as mood, hormone and temperature regulation, and sleep, are the result of an increased metabolism of melatonin and lower levels of serotonin due to circadian rhythm disturbances, commonly seen in winter months with decreased exposure to light. As such, studies examining bright light therapy in this population also assess mood symptoms.

While this effect may exist, no studies to our knowledge have experimentally examined sleep within the bright light therapy/disordered-eating literature. Only 4 of the 14 studies in this review mentioned sleep, and 2 assessed sleep improvements alongside disordered eating. Given the role of sleep disturbance in both mood disorders[50] and disordered

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eating, as well as its potential to disrupt circadian rhythm, it may be possible that individuals are seeing improvements in their disordered eating because they have improved sleep. Notably, De Young and colleagues[35] found that fatigue, as assessed by the Positive and Negative Affect Schedule–Expanded Form, was the only facet of negative affect to improve with bright light therapy administration in women with bulimia nervosa. They did not assess sleep specifically, so it is unknown if changes in fatigue correlated with changes in sleep in their sample. Also, the relationship between circadian rhythm and mood disturbances may suggest a potential mediation effect when conceptualizing sleep within a bright light therapy/disordered-eating framework (ie, Is this an intervention that improves sleep that acts as a mediator between mood and disordered eating?). For example, Blouin and colleagues[32] found decreases in depressive symptoms but no initial effect on binge/purge episodes between groups. Their bright light therapy design was the only one to specify that participants receive the intervention in the early evening, which has been shown to have a different effect on circadian rhythm synchronization compared to early morning exposure.[23] Indeed, it is possible that sleep was unaffected by the intervention in this particular study and may explain why the effect was not present on disordered eating.

This review has several limitations. Although results suggest that bright light therapy is likely efficacious for individuals regardless of eating disorder, binge-eating disorder was not included because no study assessed this particular eating disorder. Likewise, several articles included in this review were case studies, and the bulk of the remaining articles had a mean of 19 participants, an overwhelming majority of which were female. These relatively small and homogenous samples, coupled with the small number of studies, varying light box methodologies, and the presence of studies with null findings in 1 or more outcome variables, cast doubt on the internal validity of many of the studies and the generalizability validity of the conclusions in this review.

More thorough and methodologically rigorous outcome studies are needed to evaluate the efficacy and durability of bright light therapy for the treatment of eating disorders. Future studies that address these methodological limitations, as well as assess a much broader range of behavioral and physiologic systems, are necessary to advance this literature and further evaluate the empirical foundation of bright light therapy for disordered-eating behavior.

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