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The Quest for Mindful Sleep: A Critical Synthesis of the Impact of Mindfulness-Based Interventions for Insomnia

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Abstract

Mindfulness-Based Interventions (MBIs) for insomnia and sleep disturbances are receiving increasing clinical and research attention. This paper provides a critical appraisal of this growing area investigating the application of MBIs for people with insomnia and sleep disturbance. First, we discuss the theoretical justification for how mindfulness meditation practice may affect sleep processes. Second, we provide a focused review of literature published between January 1, 2012 and April 1, 2016 examining the impact of MBIs on sleep, broken down by whether insomnia or sleep disturbance was a primary or secondary outcome. Recommendations for future research are discussed.

Keywords

Mindfulness; Meditation; Insomnia; Sleep Disturbance; Intervention

Background

Insomnia is a universal concern affecting individuals across the lifespan. A multinational cross sectional survey of 25,579 individuals suggests that 35% of the population report some difficulty initiating and maintaining sleep, or non-restorative sleep at least three days per week, with 10% reporting significant daytime consequences of poor sleep (1). The most common treatment for trouble sleeping continues to be prescription sleep aids with recent estimates suggesting that 4% of the US population (approximately 11 million people) endorsed its use within the preceding 30 days (2). However, sleeping aids are associated

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with a number of negative health outcomes including increased risk for motor vehicle accidents, (3) falls and fractures in the elderly, (4) the development of comorbid psychiatric (5) and medical conditions, (6) and increased overall mortality (7), and may not be desired by patients with chronic medical illnesses (8). Considering the possible risks associated with prescription sleep aid use and the lack of efficacy data in various populations with chronic illness (9, 10), it is important to provide patients with evidence-based alternatives that fit their unique needs.

Cognitive-behavior therapy for insomnia (CBT-I) is a highly effective non-pharmacological intervention for insomnia that is considered first-line treatment for chronic insomnia disorder (11, 12). Strong evidence demonstrates that CBT-I and hypnotic medications are equally effective in the short-term, whereas the gains from CBT-I are significantly better maintained over time relative to hypnotic therapies (13–15). Despite the endorsement of CBT-I as a first-line treatment for insomnia disorder from both the National Institutes of Health (11) and the American Academy of Sleep Medicine (12) several barriers to accessing CBT-I remain. First, there is a lack of awareness among the general public (16) and primary care providers (17) to the existence of, and evidence for, CBT-I. Second, despite solid efforts to increase the number of trained professionals (18) and provide alternative delivery models (19–21), the reach of CBT-I remains limited in large part to major cities and academic medical centers (22). Lastly, insurance reimbursement for CBT-I can be poor, particularly if delivered by non-MD mental health providers (e.g. psychologists) (23).

Despite the evidence that CBT-I is an effective intervention with lasting effects (13–15) there are still a significant number of individuals whose insomnia does not fully respond to CBT-I. In a study evaluating CBT-I for persistent insomnia in adults, 40% did not report a significant treatment response and 61% continued to experience insomnia symptoms following therapy (13). One potential explanation is poor adherence to treatment (24). Several core components of CBT-I (e.g., sleep restriction and stimulus control) can be difficult to implement and often result in a short-term worsening of symptoms and patient discomfort (25, 26). It is clear that though CBT-I must be considered as a key component in the treatment of insomnia, but it may not be the right approach for every individual.

The application of Mindfulness-Based Interventions (MBIs) for insomnia and sleep disturbances is receiving increasing amounts of clinical and research attention. Mindfulness intentionally brings awareness to present moment thoughts or sensations with an attitude of acceptance, patience, openness, curiosity, and kindness which is formally practiced through meditation focused on purposefully directing ones attention towards the breath, body sensations, feelings, or thoughts (27). The practice of mindfulness meditation has been incorporated into clinical interventions as a potential pathway to more effectively decrease perceived stress and regulate emotional reactivity associated with a broad range of clinical and non-clinical conditions. Mindfulness-based techniques have recently been integrated into the treatment of insomnia because 1) they aim to directly reduce pre-sleep arousal, 2) their rationale is easily understandable, 3) they are attractive to many patients, and 4) they avoid the short-term adverse consequences sometimes seen in CBT-I. Thus, use of MBIs for insomnia and sleep disturbance may serve as a potential alternative and/or supplement to CBT-I. This paper provides a critical appraisal of this growing area investigating the application of MBIs for people with insomnia and sleep disturbance. First, we will discuss the theoretical justification for how mindfulness meditation practice may exert its effects on sleep processes. Second, we will review the literature with a focus on recent research published between January 1, 2012 and April 1, 2016. This review will be broken down by whether insomnia or sleep disturbance was a primary or secondary outcome. Lastly, recommendations for future research will be provided.

How Mindfulness Meditation May Impact Sleep

The exact mechanism(s) by which mindfulness practice works to influence sleep processes has not yet been established. Lundh and Broman suggested mindfulness might be useful in the treatment of insomnia as a means to reduce pre-sleep cognitive and physiological arousal (28). They suggested that people tend to engage in goal-directed and controlled information processing, (e.g., problem solving and decision-making) during the day and that sleep is facilitated by cognitive deactivation and a reduction in the amount of controlled and strategic information processing. This cognitive deactivation is paralleled by physiologic deactivation characterized by a decrease in muscle tone and a slowing of the cardiovascular and respiratory systems. In this way, mindfulness may help facilitate cognitive deactivation and physiological de-arousal by allowing the individual to disengage from their daily concerns and strivings. The mindfulness principles of letting go, acceptance, and non-striving are theoretically congruent to the passive nature of sleep and encourages a shifting of one’s relationship to sleep-related thoughts.

Etiological models of chronic insomnia have generally identified elevated cognitive and physiological arousal to be a key factor in the development and maintenance of sleep disturbance (29). It is unclear whether the effects of mindfulness-based stress reduction (MBSR) are stronger for physiological or cognitive arousal reduction or whether these mechanisms are addressed simultaneously. Ong and colleagues have proposed a meta-cognitive model of mindfulness exerting its influence on two levels of sleep-related arousal, suggesting that primary arousal is directly related to the belief in ones inability to sleep and the consequences of poor sleep while secondary arousal is the emotional tone and degree of attachment related to the primary arousal (30). This model hypothesizes that mindfulness might serve as a means of re-interpreting sleeplessness or reducing secondary arousal via detachment from particular modes of thinking.

Of all the repetitive thought patterns, the tendency to ruminate has been identified as an important contributing factor to the development and maintenance of insomnia (31). Compared to good sleepers, people who engage in ruminative thinking have significantly lower sleep efficiency, worse sleep quality, spend more time awake after sleep onset, and their ruminative thoughts focus on daytime symptoms of fatigue, poor concentration and low mood (32). Mindfulness meditation may allow participants to disengage from ruminative processing. Increasing the objectivity through which internal experience is viewed is intended to change one’s relationship to the thoughts, as opposed to changing the thoughts themselves and has been referred to as re-perceiving (33). Shapiro, Carlson, Astin and Freedman suggest that re-perceiving may account for the salutary effects of mindfulness-based stress reduction (MBSR) by increasing self-regulation, clarifying values, promoting cognitive, emotional and behavioral flexibility, and allowing for the development of tolerance for, or a desensitization to, difficult emotional states through exposure (33). The hypothesized mechanisms of mindfulness were reviewed in a recent meta-analysis of 20 studies using mediation analyses of MBSR and mindfulness-based cognitive therapy (MBCT) (34). The authors found consistent evidence for a reduction in repetitive negative thinking as a mechanism of the effect of mindfulness on psychological outcomes. As such, mindfulness-based programs that reduce rumination via meta-cognitive processes may provide a unique treatment option for insomnia (35); however, further research is needed to properly investigate this possibility.

Others have postulated that mindfulness may provide a vehicle to counter the attentional biases that occur in patients with insomnia (36). Attention bias in insomnia refers to the tendency to selectively pay attention to perceived internal or external threats to sleep or the consequences of poor sleep (37). Mindfulness begins by training oneself to pay attention to present moment experience and to redirect attention back to the focal point (e.g., breathing) should it become distracted by some thought. With repetition, it becomes easier to recognize these biases and the practice of distancing oneself from these thoughts is hypothesized to result in reduced sleep-interfering emotional and cognitive arousal (36).

It is likely that the hypotheses presented above for how MBIs might impact sleep are interrelated and simultaneously explain different, but connected, pieces of the puzzle. Physiological arousal will be noticed and create cognitive arousal. Thinking patterns that create unpleasant emotional states like rumination or attentional bias, which produces an anticipation of harm, will result in increased physiological arousal. Because patients with insomnia vary in cognitive styles and arousal thresholds, MBI aims to reduce insomnia by addressing both cognitive and physiological arousal.

The Evidence for Mindfulness-Based Interventions for Insomnia

While this review is not intended to be a formal systematic review, we performed a thorough literature search of published research from January 1, 2012 to April 1, 2016 using PubMed, PsycInfo, and Medline and the following search terms: sleep, insomnia, mindfulness, Mindfulness-Based Stress Reduction, Mindfulness-Based Cognitive Therapy, MBSR, MBCT, Mindfulness-Based Therapy for Insomnia, and MBT-I. Reference lists of the retrieved articles were also reviewed. We included articles that were published in English, conducted with adult populations, included a subjective or objective measure of sleep as a primary or secondary outcome, and used a mindfulness-based intervention. Eighteen studies were identified; 7 assessed sleep as a primary outcome and 11 included sleep measures as a secondary outcome.

Sleep as a Primary Target of Mindfulness-Based Interventions

Of the 7 studies that specifically investigated the impact of mindfulness-based interventions on sleep outcomes, 6 were randomized controlled trials. Five of the studies assessed the impact of MBIs in patients with clinically diagnosed insomnia while the remaining two assessed more general sleep disturbances. Three of the studies were conducted with adults (one study only included women), two with older adults, and two in patients with cancer. The total sample including all the studies was 407 with the samples of individual studies ranging from 12 to 111. Of the 6 randomized controlled studies, 5 compared MBIs to different interventions and/or included active control groups. The details of these studies are provided in Table 1.

The type of MBIs investigated in these studies varied, and often a MBI was compared to another active non-mindfulness-based treatment. For example, Wong, Ree, and Lee (38) conducted a comparative effectiveness trial in 64 individuals with insomnia. All participants completed an individually-delivered 4-week CBT-I intervention and then were randomly assigned to either 4 more sessions of cognitive therapy (CT) or mindfulness-based therapy (MBT) either immediately or after a 4-week waiting period. The MBT intervention focused on developing mindfulness skills through formal and informal meditation practice and participants were encouraged to practice before bed, upon awakening, and at any other time they desired during the day. There was a statistically and clinically significant effect of CBT-I at 4 weeks on insomnia severity, sleep continuity and quality, and psychological functioning. Treatment with an additional 4 weeks of CT or MBT was associated with further improvements, but no significant between-group differences were found. While the design is novel, the most significant limitation of this study is that the first author delivered all of the interventions. It is also not clear whether similar benefits would have been observed if participants had received an additional 4 weeks of CBT-I.

The effectiveness of a modified version of MBSR titled Mindfulness-Based Cancer Recovery (MBCR) compared to CBT-I was evaluated in a sample of 111 cancer survivors with insomnia (39). Both interventions were delivered to groups over the course of 8 weeks. Using a non-inferiority margin of four points on the Insomnia Severity Index (40), MBCR demonstrated inferiority to CBT-I when assessed immediately after the program but was within the non-inferiority margin at the 3-month follow up. CBT-I produced larger improvements in diary-measured sleep latency and sleep efficiency but both interventions significantly reduced amount of time spent awake after sleep onset and increased total sleep time. Significant reductions in symptoms of stress and psychological distress were also reported for both groups. The authors concluded that CBT-I remains the treatment of choice for insomnia but that MBIs should be considered a viable alternative for certain patients interested in an acceptance-based treatment approach. These may include patients interested in a mindfulness-based treatment approach, patients for whom CBT-I has been unsuccessful in the past, and patients unable or unwilling to implement challenging aspects of CBT-I such as sleep restriction (e.g., due to fatigue during chemotherapy for cancer). Future research is encouraged to apply an individualized or preference-based approach to evaluating the effectiveness of insomnia interventions.

Based on his meta-cognitive theory of insomnia, Ong et al. (41) developed an adaptation of MBSR specifically to insomnia called Mindfulness-based Therapy for Insomnia (MBT-I). This 8-week group intervention teaches the behavioral strategies of CBT-I (sleep restriction, stimulus control and sleep hygiene), and replaces the cognitive components of CBT-I with the discussion and practice of mindfulness meditation. The effectiveness of MBT-I was assessed by comparing it to an 8-week traditional MBSR group program and a self-monitoring (SM) control group in a sample of 54 individuals with chronic insomnia disorder with follow ups conducted at 3- and 6-months post-treatment. The effect sizes for reducing insomnia severity post-treatment using the Insomnia Severity Index (ISI; (42)) were 1.33, 2.07 and 0.01 for the MBSR, MBT-I, and SM groups, respectively. The 6-month effect sizes were 1.57 for MBSR and 2.56 for MBT-I. Response to treatment (defined as a >7 point reduction in ISI scores) and remission rates (defined as an ISI score <8) remained relatively constant in the MBSR group during the follow-up period (approximately 39%). However, the MBT-I group continued to report gains after treatment with 50% achieving remission and 70% exhibiting a treatment response by 6 months. Because this study did not compare their intervention to standard CBT-I, it was not possible to determine the additive benefit of mindfulness training above the behavioral interventions provided in the MBT-I group.

Black et al. (43) extended their examination of MBI on sleep disturbances by incorporating a proposed biological marker of inflammation (nuclear factor-κB) that is associated with sleep disruption. The study compared a low-cost community MBI known as Mindful-Awareness Practices (MAPs) to a Sleep Hygiene Education (SHE) group in 49 older adults with sleep disturbances. The MAPs group was a weekly 2-hour, 6 session group-based course, designed to instruct participants in mindfulness meditation practice. The SHE intervention was matched for time, attention, expectancy, and group effect. The content of SHE consisted of psychoeducation about sleep and stress as well as relaxation training and sleep hygiene instructions. Only the MAPS group reported a significant improvement in sleep quality after program completion and improved sleep was associated with increased mindfulness. While no significant effect was observed for the secondary measure of nuclear factor-κB, this study will likely be followed by many more determined to discover whether improved sleep produced by non-pharmacological interventions can translate into improved health at a cellular level.

In sum, the evidence from randomized trials indicate that MBIs can contribute to reduced insomnia severity and sleep disturbance in healthy individuals, people with chronic disease, and older adults. These results do not appear to favor one particular type of meditation training program, any specific population, or age group. However, future research can compare the efficacy of various MBIs and identify groups of patients for whom MBIs are particularly effective.

Sleep as a Secondary Target of Mindfulness-Based Interventions

Of the 11 studies that investigated the impact of mindfulness-based interventions on sleep as a secondary outcome, 7 were randomized controlled trials. Five of the studies assessed the impact of MBIs on sleep in people with cancer, 2 studies were conducted in patients with depression, 2 studies were conducted in patients with pain conditions, one study was conducted in people with diabetes and coronary heart disease, and one in people reporting high levels of subjective stress. The sample size of individual studies ranged from 25 to 336. Sleep was assessed using validated measures in 8 of the 11 studies, with the remaining three using single items from other measures. Details of these studies can be found in Table 2.

One novel study conducted by van der Zwan et al. (44) compared self-guided physical activity (PA), mindfulness meditation (MM), and heart rate variability biofeedback (BF) in a sample of 126 participants suffering from stress. All three interventions consisted of a single 2 hour session where participants were instructed and practiced their assigned intervention: 1) the PA group was instructed to engage in vigorous exercise of their choosing; 2) the MM group was provided readings and a CD with guided meditations for home practice; 3) the BF group was provided with an infrared finger photoplethysmograph and a brochure with instructions on breathing exercises. Participants were instructed to do daily exercises at home increasing in duration from 10 minutes per day in the first week to 20 minutes per day at week 5. A statistically significant improvement in sleep quality (measured by the Pittsburgh Sleep Quality Index; PSQI (45)) was demonstrated for the MM group only, though it did not translate into a clinically significant change. The primary intervention target (perceived stress) is a mechanism by which the mindfulness-based practices are theorized to improve perceptions of overall sleep quality.

When considering the potential impact of MBSR on sleep outcomes, the work conducted by Lengacher et al. (46) provides an important cautionary lesson. The study authors included sleep as a secondary outcome in a randomized trial comparing a 6-week MBSR program in women with early-stage breast cancer (n=38) to a usual care control group (n=41). The sample did not include individuals with clinically significant sleep issues at baseline. Specifically, the baseline total PSQI score was 8, and while this would not be characteristic of “good” sleepers (47), patients diagnosed with insomnia included in other intervention trials have typically reported PSQI values closer to 13 (39, 48). Not surprisingly, no subjective sleep improvements were noted, and the statistically significant increase in sleep efficiency, and decreased number of awakenings as measured by actigraphy had minimal clinical relevance. Additionally, the actigraph was only worn for 3 days at each assessment time, making it susceptible to one particularly good night of sleep. In efforts to establish the efficacy of MBIs for insomnia and/or sleep disturbances researchers must design trials with appropriate samples to avoid potential floor effects and allow the full potential of the intervention to be tested.

In all, the research investigating the impact of MBIs on sleep as a secondary outcome has considerable diversity. Of the remaining studies that assessed sleep as a secondary outcome of an MBI intervention, 3 found MBI significantly reduced subjective insomnia or sleep disturbance and 6 found no effect. However, these studies have several limitations and may have been underpowered to detect effects on insomnia or sleep disturbance. Specifically, a number of studies did not include validated stand-alone sleep measures; instead, sleep quality/insomnia was a single item part of a larger quality of life instrument. As noted above, the populations did not always present with significant sleep issues at baseline, making it a difficult test of MBIs ability to improve sleep outcomes. Finally, it is also not clear if the effects of MBI on sleep were direct or whether they were mediated by reductions in the primary symptom (e.g., pain, fatigue).

Discussion

The studies reviewed found significant impacts of MBIs on insomnia and sleep disturbance, and these effects were especially strong in studies primarily aimed at improving sleep. Findings were more mixed in studies that examined sleep as a secondary outcome, particularly those which did not seek to recruit a patient population who were experiencing active insomnia symptomatology. Although recent research has advanced the field of MBIs as a viable treatment option for patients with insomnia, critical questions remain about mechanism(s) of function and the delivery of treatment.

One important area for future examination is identifying the mechanisms by which MBIs improve insomnia symptoms. One theory posits that MBIs reduce insomnia through their impact on attention bias and improved emotion regulation; however, longitudinal meditational models are needed to test whether reductions in cognitive and physiological arousal from mindfulness training is associated with subsequent improvements in sleep. Further, the necessary MBI ‘dosage’ is unclear. Future studies should compare several lengths and intensities of treatment to ensure efficacy is optimized without inconveniencing patients, as has been done with CBT-I (49). This type of research would be helpful to develop a sense of treatment burden and will likely result in opportunities to refine MBIs in order to streamline the intervention process for patients.

As CBT-I is recognized to be front-line therapy, and hypnotic medications are commonly dispensed in the treatment of insomnia, it is necessary to directly compare the efficacy of MBIs to these interventions. To date, only one study has compared an MBI to the recommended first-line treatment, CBT-I (39), and one other has compared MBIs to hypnotic medications (50). Both studies found no differences in long-term efficacy for reducing insomnia severity. In particular, one important benefit of CBT-I over pharmacologic therapy has largely been overlooked in the MBI literature. Studies have shown that whereas the efficacy of pharmacotherapy wanes after treatment is discontinued, CBT-I demonstrates efficacy for as long as two years after the intervention has completed (51). Future studies of MBIs should include long-term follow-up periods now that evidence has conclusively shown the short- and medium-term efficacy for reducing insomnia (41, 43). Properly powered studies should aim to determine which of the various treatment options are most efficacious in both the short and long-term.

Beyond the direct comparison between MBIs and other treatment modalities, another opportunity for future study is determining which patients may benefit most from each type of therapy. Studies should compare the efficacy of MBIs in populations for which a component of one or more alternative treatment options may pose a significant barrier. For example, patients with some chronic illnesses (e.g., cancer, kidney disease) experience significant fatigue (52, 53) and may be unwilling or unable to adhere to the sleep restriction component of CBT-I. There may also be important patient factors that can moderate the impact of some treatment options, including severity of insomnia, age, and gender. Similarly, some patients may prefer a cognitive-behaviorally based treatment over one based in mindfulness theory. For example, Garland and colleagues reported drop-out rates of 52% and 15% within the first 3 weeks of starting MBSR and CBT-I groups, respectively when participants were recruited for the trial without knowing what interventions were being compared (39). Investigators should study whether patient preference may impact efficacy of, or retention in, MBIs for insomnia.

Future studies should also explore the benefits of administering MBIs in assorted modalities. Internet-delivered CBT-I has demonstrated efficacy comparable to that of face-to-face CBT-I (20, 54). Delivery via the Internet significantly increases the disseminablity of an intervention, can reduce the cost considerably, and may eliminate other barriers to treatment for insomnia, including time constraints and difficulty traveling. We are unaware of any randomized clinical trials that have tested Internet-delivered MBIs for insomnia, but mobile and eHealth adaptations of MBIs in other populations have been developed and evaluated (55–57). Future studies should capitalize on this and other opportunities to spread the reach of MBIs.

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Table 1

Review of studies with sleep as a primary outcome since 2012 (in alphabetical order)

First Author	Date	Intervention Details	Sample/Sex Population	Type of Study	Sleep Outcome	Additional Measures	Results
Black (43)	2015	Group 6-week (2 hours/week) MAPS or SHE	49 (33F;16M) Older adults w/ sleep disturbances	RCT	FSI, PSQI	AIS, BAI, BDI, FF-MQ, FMQ, PSS	MAPS intervention resulted in greater improvement in sleep quality compared to SHE intervention
Garland (39)	2014	Group 8-week (90 mins/week) MBSR or CBT-I	111 (80F;31M) Cancer patients w/ insomnia	Noninferiority RCT	Actigraphy, DBAS, ISI, PSQI, sleep diary	C-SOSI, POMS	MBSR was inferior to CBT-I immediately post treatment but both MBSR and CBT-I produced improvements in sleep problems and psychological outcomes; at 3mo follow up
Larouche (58)	2015	Group 8-week (2.5 hours/week) MBCT	12 Females w/ insomnia	Single group Pre-post	Actigraphy, DBAS, ISI, PAS, sleep diary, TCQIR	FF-MQ, IIS, PSWQ	Sleep efficacy improved, total wake time decreased, nocturnal awakenings decreased. After 3 months, significant improvements in quality of sleep, morning awakenings, and total sleep time
Nakamura (59)	2013	Group 3-week (2 hours/week) MBB, MM, or SHE	57 (43F;14M) Cancer survivors w/ sleep disturbance	Pilot RCT	MOS-SS	CES-D, FACT- G, FF-MQ, IES, PANAS, PSS, SCS, WBI	MBB and MM both superior to SHE in decreasing sleep disturbance. Both MBB and MM found to be equally effective at treating sleep disturbance in cancer survivors
Ong (41)	2014	Group 8-week (2.5 hours/week) MBSR, MBTI or 8-week SM	54 (40F;14M) Adults w/ insomnia	RCT	Actigraphy, ISI, PSAS, sleep diary		Both mindfulness interventions superior to SM on all sleep measures but no significant differences found between MBSR and MBTI
Wong (38)	2015	Individual 4-week CBT (1 hour/week), then 4-week (1 hour/week) CT, MBT or no further treatment	64 (40F;24M) Adults w/ insomnia	Stepped RCT	Actigraphy, ISI, PSQI, sleep diary	DASS	Significant reductions in insomnia severity, improvements in TST, WASO, and sleep efficiency with both CT and MBT. No significant differences between CT or MBT on sleep outcome measures
Zhang (60)	2015	Group 8-week (2 hours/week) MBSR	60 (25F; 35M) Older adults w/ insomnia	RCT	PSQI	GDS, SAS	MBSR reduced PSQI scores and depression symptoms. No significant change in anxiety symptoms after MBSR

AIS- Athens Insomnia Scale; BAI- Beck anxiety Inventory; BDI- Beck Depression Inventory; CBT-I- Cognitive Behavior Therapy for Insomnia; CES-D- Center for Epidemiological Studies-Depression Scale; C-SOSI- Calgary Symptoms of Stress Inventory; CT- Cognitive Therapy; DASS- Depression, Anxiety and Stress Scale; DBAS- Dysfunctional Beliefs and Attitudes About Sleep Scale; FACT-G-

Functional Assessment of Cancer Therapy-General; FF-MQ- Five Facet Mindfulness Questionnaire; FMQ-Facet Mindfulness Questionnaire; FSI- Fatigue Symptom Inventory; GDS- Geriatric Depression Scale; IES- Impact of Event Scale; IIS- Insomnia Interview Schedule; ISI- Insomnia Severity Index; MAPS-Mindfulness Awareness Practices Intervention; MBB- Mind Body Bridging; MBCT-Mindfulness Based Cognitive Therapy; MBSR- Mindfulness Based Stress Reduction; MBT-Mindfulness Based Therapy; MBTI- Mindfulness Based Therapy for Insomnia; MM- Mindfulness Meditation; MOS-SS- Medical Outcomes Study Sleep Scale; PANAS- Positive and Negative Affect Schedule; PAS- Pre-Sleep Arousal Scale; POMS- Profile of Mood States; PSAS- Pre-Sleep Arousal Scale; PSQI-Pittsburgh Sleep Quality Index; PSS- Perceived Stress Score; PSWQ- Penn State Worry Questionnaire; RCT- Randomized Controlled Trial; SAS- Self-Rating Anxiety Scale; SCS- Self-Comparison Scale; SHE- Sleep Hygiene Education; SM- Self-Monitoring; TCQIR- Thought Control Questionnaire- Insomnia Revised; WBI- Well-being Index

Table 2

Review of studies with sleep as a secondary outcome since 2012 (in alphabetical order)

First Author	Date	Intervention Details	Sample/Sex Population	Type of Study	Sleep Outcome	Additional Measures	Results
Andersen (61)	2013	Group 8-week (2 hours/week) MBSR	336 Females w/ breast cancer	RCT	MOS-SS	SCL-90-R, hot flush score	MBSR increased sleep quality just after the intervention but had no long-term effects among patients
Björnsdóttir (62)	2015	Group 4-week TMP, or NEM and MBCT	269 Females w/ chronic pain for at least 6 months	Cohort study	Sleep domain of IQL	IQL, VAS	Both NEM and TMP improved pain and HRQL. NEM participants showed greater reduction in sleep disturbances, while TMP participants showed a greater reduction in pain intensity
Bower (63)	2015	Group 6-week (2 hours/week) MAPS	71 Females w/ early stage breast cancer at or before age 50	RCT	FSI, PSQI	BCPT, CES-D, FACIT, IES, PANAS-PA, PSS, QLACS	MAPS intervention led to reductions in perceived stress, depressive symptoms, fatigue, sleep disturbance, and proinflammatory signaling
Cash (64)	2014	Group 8-week (2.5 hours/session) MBSR	91 Females w/ fibromyalgia	RCT	SSQ, FSI	BDI, CTQ, FIQ, PSS, VAS	MBSR significantly reduced perceived stress, sleep disturbance, and symptom severity. MBSR had no effect on pain, physical functioning, or cortisol levels
Dobos (65)	2015	Group 11-week (6 hours/week) mindfulness-based day care clinic group program	117 (106F;11M) Cancer survivors	Cohort study	Single item on EORTC QLQ- C30	AKU, BMLSS, EORTC QLQ- C30, FMI, HADS, SpREUK, IIQ	Improvements in global health status, physical and emotional functioning. Significant reductions in fatigue, pain, insomnia, constipation, anxiety, and depression
Foulk (66)	2014	Group 8-week MBCT	50 (32F;18M) Older adults w/ depression and/or anxiety	Pre-post	SPS	GDS-15, HADS RRS-10	Significant improvements in sleep problems, anxiety, ruminative thoughts, and a reduction in depressive symptoms
Johns (67)	2015	Group 7-week (2 hours/week) MBSR	35 (33F; 2M) Cancer survivors w/ cancer-related fatigue	Pilot RCT	ISI, FSI, vitality scale of SF-36 Health Survey	PHQ-8, PHQGADS, SDS	MBSR intervention produced significant reductions in fatigue interference, fatigue severity, depression, and sleep disturbance compared to control group.
Keyworth (68)	2014	Group 6-week (2 hours/week) meditation and mindfulness intervention	40 (21F;19M) Diabetes mellitus and/or coronary heart disease	Mixed methods pilot study	Single item on PSWQ	PSWQ, WBSI, a comorbidity burden scale	Improved sleep, greater relaxation, greater acceptance of illness and illness

First Author	Date	Intervention Details	Sample/Sex Population	Type of Study	Sleep Outcome	Additional Measures	Results
							experience, reduction in worry and thought suppression
Lengacher (46)	2014	Group 6-week (2 hours/week) MBSR(BC)	79 Females w/ breast cancer	RCT	Actigraphy, PSQI, sleep diary		MBSR(BC) participants showed reduced sleep disturbances and improved sleep efficacy compared to UC group
Schramm (69)	2016	Group 8-week (2 hours/week) MBCT or CBASP	25 (16F;9M) Depression	Pilot RCT	PSQI, sleep diary	BDI, EEG, HDRS	CBASP group had less wake than MBCT and TAU groups, and greater stable sleep than TAU group
van der Zwan (44)	2015	Group 5-week PA, MM, or HRV-BF	75 (55F; 20M) Adults who suffer from stress	RCT	PSQI	DASS, SPW	PA, MM, and HRV-BF all equally effective at reducing stress, anxiety and depressive symptoms, and improving psychological well-being and sleep quality

AKU- Adaptive Coping with Disease Questionnaire; BCPT- Breast Cancer Prevention Trial Symptom Checklist; BDI- Beck Depression Inventory; BMLSS- Brief Multidimensional Life Satisfaction Scale; CBASP- Cognitive Behavioral Analysis System of Psychotherapy; CES-D- Center for Epidemiological Studies-Depression Scale; CTQ- Childhood Trauma Questionnaire; DASS- Depression, Anxiety and Stress Scale; EORTC QLQ-C30- European Organization for Research and Treatment of Cancer Quality of Life Questionnaire; FACIT- Functional Assessment of Chronic Illness Therapy; FIQ- Fibromyalgia Impact Questionnaire; FMI- Freiburg Mindfulness Inventory; FSI- Fatigue Symptom Inventory; GDS-15- Geriatric Depression Scale-Short Form; HADS- Hospital Anxiety and Depression Scale; HDRS- Hamilton Depression Rating Scale; HRQL- Health Related Quality of Life; HRV-BF-heart rate variability biofeedback; IIQ- Interpretation of Illness Questionnaire; IQL- Icelandic Quality of Life scale; ISI- Insomnia Severity Index; MAPS-Mindfulness Awareness Practices Intervention; MBCT- Mindfulness Based Cognitive Therapy; MBSR- Mindfulness Based Stress Reduction; MBSR(BC)- Mindfulness Based Stress Reduction for Breast Cancer; MM- Mindfulness Meditation; MOS-SS- Medical Outcomes Study Sleep Scale; NEM- Neuroscience Education; PA- Self-help Physical Activity; PANAS-PA- Positive and Negative Affect Schedule-Positive Affect; PHQGADS- Patient Health Questionnaire Generalized Anxiety Disorder Scale; PSQI- Pittsburgh Sleep Quality Index; PSS- Perceived Stress Score; PSWQ- Penn State Worry Questionnaire; QLACS- Quality of Life in Adult Cancer Survivors; RCT- Randomized Controlled Trial; RRS-10- Ruminative Responses Scale; SCL-90-R- Symptom Checklist 90 Revised; SDS- Sheehan Disability Scale; SpREUK- Spiritual and Religious Attitudes in Dealing with Illness; SPS- Sleep Problems Scale; SPW- Scales of Psychological Well-being; SSQ- Stanford Sleep Questionnaire; TMP- Traditional multidisciplinary pain management program; VAS- Visual Analogue Scale; WBSI- White Bear Suppression Inventory