HHS Public Access

Author manuscript

Curr Oncol Rep. Author manuscript; available in PMC 2020 August 13.

Published in final edited form as:

Curr Oncol Rep. 2017 September ; 19(9): 60. doi:10.1007/s11912-017-0621-6.

Mindfulness-Based Interventions and Sleep Among Cancer Survivors: a Critical Analysis of Randomized Controlled Trials

Georgia Christodoulou[1], **David S. Black**[1,2]

[1]Department of Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, CA, USA

[2]Norris Comprehensive Cancer Center, University of Southern California, Los Angeles, CA, USA

Abstract

Purpose of review—The purpose of our critical examination is to present results and provide a synthesis of this body of work. *Recent findings* Sleep problems among cancer survivors are gaining research attention. To our knowledge, there have been six randomized control trials published from 2013 to 2015 that test the effects of mindfulness-based interventions (MBIs) on sleep as a primary or secondary outcome.

Summary—Our examination of the literature highlights important methodological issues and variability among trials. We conclude our review by offering solutions to facilitate more scientific rigor in future studies.

Keywords

Mindfulness; Sleep; Cancer; Survivors; Insomnia

Introduction

Efficacy testing of mindfulness-based interventions (MBIs) for symptom reduction among cancer survivors is growing [1, 2]. Anticipated benefits of MBIs for symptom reduction stems from learning acquired during expe riential practices in mindfulness. This learning program allows for a greater spectrum of adaptive responses to distressing situations by increasing awareness of thought processes, experiences arising in the present moment, and attention to somatic experience in those moments without judgment [3, 4]. MBIs used to remediate sleep problems is a newer area of investigation [3, 4], especially among cancer survivors.

Cancer diagnosis, treatment, and historical disease exposure predict survivors' elevated levels of distress, anxiety, and poor sleep [5, 6]. Sleep problems can be complex and driven by unintended effects of clinical treatment and related biological shifts in hormonal balance

David S. Black, davidbla@usc.edu.

Conflict of Interest Georgia Christodoulou and David S. Black declare they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

and inflammatory signaling [7, 8]. These problems can also lead to cognitive and mood perturbations that can alter physiological arousal states prior to sleep, such as worrying about not getting enough sleep when feeling anxious [3, 9]. The prevalence of insomnia in survivors undergoing chemotherapy treatment is three times that of non-cancer populations [10], and poor sleep can persist and limit quality of life in survivors for months and even years following treatment [11].

Our purpose for this article is to review and critically examine the literature that tests the efficacy of MBIs on sleep outcomes among cancer survivors, a population we define here as individuals with cancer from the time of diagnosis onward [12]. We focus our examination on 6 RCTs published from 2003 to 2015 that test the efficacy of MBIs on subjective and/or objective sleep parameters as primary or secondary outcomes. We then attempt to synthesize major strengths and limitations in this field. Our intent is to learn from past investigations and their methodologies to inform future efficacy testing of MBIs on sleep outcomes among cancer survivors.

RCTs Assessing Sleep as the Primary Outcome

Only two RCTS have tested the effects of MBIs on sleep as a primary outcome, both published in 2014 or thereafter [13••, 14••]. Garland et al. [13••] conducted a non-inferiority RCT investigating the effects of Mindfulness-Based Stress Reduction (MBSR) on insomnia compared to Cognitive Behavioral Therapy for Insomnia (CBT-I) among 111 cancer survivors (48% breast cancer) who had completed treatment. MBSR included 8, 90-min sessions with a 6-h silent retreat (18 contact hours total), while CBT-I included 8, 90-min sessions (12 contact hours total). A diagnosis of insomnia was required for enrollment, defined as sleep disturbances occurring three or more days a week for 1 month minimum, less than 85% sleep efficiency, and greater than 30 min sleep latency or time awake after sleep. The primary outcome was assessed via the Insomnia Severity Index (ISI), a 7-item self-administered questionnaire. An 8-point reduction on the ISI was considered clinically important, and the noninferiority margin was set to a 4-point difference. Secondary outcomes included the sleep diary (assessing sleep efficiency (SE), sleep onset latency (SOL), wake after sleep onset (WASO), and total sleep time (TST)), the Pittsburgh Sleep Quality Index (PSQI), and the wrist-worn actigraphy device (assessing SE%, SOL, WASO including early morning awakenings, and TST).

Garland et al. [13••] utilized intent-to-treat (ITT) and per-protocol (PP) analyses to assess between-group mean differences on the ISI and secondary outcome measures. Results showed that participants in CBT-I improved more on the ISI at post-treatment compared to MBSR; however, both programs showed significant long-term improvement. MBSR demonstrated noninferiority to CBT-I at 5-month follow-up (3 months following post-treatment) (difference in ISI mean score in MBSR and CBT-I was 2.07 (PP) and 2.02 (ITT), respectively). There were significant interactions between the MBSR and CBT-I groups on sleep diaries (SOL and SE%), PSQI, and dysfunctional sleep beliefs with greater improvement in the CBT-I group. There was also significant group and time effects for WASO and TST. Both groups demonstrated significant improvement in WASO from baseline to follow-up, while CBT-I showed the greatest improvement at 2-month follow-up

(post-treatment). Significant changes in TST were found with MBSR exceeding CBT-I on improvement from 2-month to 5-month follow-up. No significant interactions were found on actigraphy assessments. Effect sizes of within-group impact of treatment for MBSR on the ISI from baseline to 2-month and 5-month follow-up were large (Cohen's d = 1.39–1.52 (ITT) and 1.36–1.60 (PP)). Additional within-group effect sizes for MBSR were of moderate to large magnitude (PSQI, Cohen's d = 0.62–1.04 (ITT) and 0.91–1.38 (PP)); SOL minutes in sleep diary, Cohen's d: 0.29–0.78 (ITT) and 0.19–0.86 (PP); SE% in sleep diary, Cohen's d: 0.62–0.94 (ITT) and 0.64–1.03(PP). Dropout rates significantly differed with increased attrition within the MBSR group compared to CBT-I (50 vs. 15%, respectively at 2-month follow-up). Researchers postulated that patient preference and motivation played a role, since many potential participants were ineligible for the study due to previous experience with MBSR. Benefits on sleep associated with mindfulness as opposed to CBT-I may not have been as apparent for these participants.

Lengacher et al. [14••] conducted a two-armed RCT to assess sleep as a primary outcome and tested the efficacy of MBSR compared to usual care among 79 breast cancer survivors recruited from a larger parent trial. Participants were required to have a diagnosis of stage 0–III breast cancer and have completed their cancer treatment within 2 weeks to 2 years prior to enrollment. Sleep disturbances or related disorders were not required. The inactive control group, waitlisted to receive the MBSR intervention, underwent usual treatment (post-treatment clinic visits). Participants receiving MBSR completed 6, 2-h weekly sessions and were assigned to practice meditative techniques. Participants wore wrist-worn actigraphy devices to capture objective measures of sleep, including SOL, SE%, WASO, number of waking bouts, and TST. Subjective measures included the PSQI and sleep diary, assessing bedtime, time to sleep, rising time, number of sleep hours, and consequences of sleep difficulty. Researchers used analysis of covariance to examine mean changes by group in sleep outcome scores from baseline to 6 weeks and 6 weeks to 12 weeks. There were no significant between-group differences on sleep measures and actigraphy assessment (excluding WASO; $p < .01$) at baseline; participants altogether had a mean PSQI score of 8.19 (±4.36) and slept an average of 7.09 (±1.32) hours a night (a score on the PSQI greater than 5 indicates presence of sleep disturbance) [15]. However, baseline mean sleep efficiency scores among all participants were relatively high at approximately 80%. Participants in the MBSR group improved more than controls based on actigraph measurements, specifically SE% (78.2 versus 74.6%; Cohen's d = 0.33) and number of waking bouts from 6 to 12 weeks (93.5 versus 118.6; Cohen's d = 0.39). There were no significant differences between groups on subjective sleep measures. There were also no significant effects of MBSR practice on subjective and objective sleep measures, although quantification of practice time among participants was not provided.

RCTs Assessing Sleep as the Secondary Outcome

Shapiro et al. [16••] tested the efficacy of MBSR against a free-choice (FC) control group on psychological distress among 63 women with stage II breast cancer who had completed treatment as part of a larger RCT. Sleep disturbances or related disorders were not required for enrollment. Participants assigned to MBSR were given 6, 2-h weekly sessions and a 6-h silent retreat. The FC group did not receive a formal intervention; instead, participants were

encouraged to engage in stress management activities on their own. Participants completed sleep diaries that quantified SOL, number and duration of awakenings, TST, sleep quality, and SE%. Researchers also asked participants to rate their quality of sleep for the previous night and how rested/refreshed they felt in the morning on a 10-point scale. Because initial baseline differences were detected in psychological distress (primary outcome) among groups, researchers conducted subsequent analyses as "quasi-experimental," accounting for nonequivalence between MBSR and the control group. Researchers utilized hierarchical regression modeling with mixed effects coefficients to assess change over time in sleep scores, adjusted for baseline levels of psychosocial distress and sleep quality. Baseline analyses of all participants showed a mean of 0.88 for SE%, 6.53 h total sleep, 6.1/10 for feeling rested, and 6.6/10 for quality of sleep. No between-group differences on sleep measures were found. Formal mindfulness practice did not demonstrate a significant association with SE%. However, those who practiced more mindfulness informally showed significantly more feelings of being refreshed after sleep over time regardless of group assignment (interaction of informal mindfulness and time: beta = 0.34).

Andersen et al. [17••] conducted a RCT to test the efficacy of MBSR against treatment-as-usual on anxiety and depression among 336 women with stages I–III breast cancer, diagnosed within 3–18 months prior to enrollment. Sleep disturbances or related disorders were not required for enrollment. Patients still undergoing cancer treatment post-surgery were also enrolled. The secondary outcome of sleep was assessed via the 12-item Medical Outcome Study sleep scale (MOS); outcomes are evaluated from seven subscales and two indices, sleep problem index I and II (SPI-I, SPI-II). SP-II represents an overall measure of sleep disturbance, adequacy, awakening with shortness of breath/headache, and daytime somnolence. "Optimal Sleep" was categorized on a dichotomous scale of 0–1 with participants responding if they slept an optimal 7–8 h a night. Participants in the MBSR group received 8, 2-h, weekly sessions with a 5-h silent retreat and were encouraged to meditate at home. Researchers utilized student t test analyses to compare mean subscale sleep scores by group at baseline versus post-intervention, 6- and 12-month follow-up. Results showed significant improvement in sleep quality from baseline to post-intervention in MBSR on SPI-I ($M = 25.39$, $p = 0.03$), SPI-II ($M = 26.04$, $p = 0.03$), and MOS sleep disturbance ($M = 24.91$, $p = 0.03$). MBSR marginally outperformed the control group on SPI-II (mean difference of −4.24 (MBSR) versus −0.79 (control), $p = 0.05$, Cohen's $d = 0.24$) from baseline to post-intervention. There were no significant differences between groups from baseline to the follow-up periods (except for reports of daytime somnolence). Attrition within the MBSR group was higher than controls at 12-month follow-up (28 versus 15%, respectively).

Bower et al. [18••] conducted a two-armed RCT to test the efficacy of the Mindful Awareness Practices (MAPS) program against a wait-list control group on perceived stress and depressive symptoms among 71 premenopausal women diagnosed with stage 0–III breast cancer. Participants included cancer survivors up to 10 years following initial diagnosis, who had completed treatment (excluding hormonal therapy). Sleep disturbances or related disorders were not a requirement for enrollment. Participants assigned to MAPS received 6, 2-h, weekly sessions and meditation practice as homework. Participants completed the PSQI at baseline, post-intervention, and 3-month follow-up. Participants in

both groups had mean PSQI scores >8, indicating poor sleep quality. Linear mixed effects models were utilized for analyses of group differences on PSQI scores over time. Results showed that MBSR outperformed controls on improved sleep quality at post-intervention (M = 6.48 (±0.65) (MAPS) versus M = 8.70 (±0.71) (control), p = 0.015). This advantage was not observed at 3-month follow-up.

Johns et al. [19••] conducted a RCT to test the efficacy of MBSR against a wait-list control group on fatigue among 35 cancer patients (85.7%), who had clinically significant fatigue and were no longer in treatment (excluding endocrine therapy). Researchers did not utilize enrollment criteria related to sleep. Participants completed the ISI as a secondary outcome. Participants assigned to the MBSR group received 7, 2-h, weekly sessions and meditation homework assignments. The original MBSR program was reduced to account for fatigue. Analysis of covariance was utilized to detect significant mean differences on ISI scores between groups at post-intervention and 1-month follow-up, adjusted for baseline scores. Paired t tests measured within-group improvement on outcomes following the MBSR intervention to 6-month follow-up for both groups. Baseline scores on the ISI indicated subthreshold levels of insomnia (M = 11.17 (±6.67) (MBSR) versus M = 13.29 (± 7.05) (control)). Results showed that MBSR outperformed controls on improved ISI scores (reduction in total score) at post-intervention and 1-month follow-up with effects sizes of −0.74 (p = 0.001) and −1.00 (p < 0.001), respectively. Analyses of the wait-listed control group also demonstrated within-group improvement on assessed outcomes; however, detailed statistics were not included.

Conclusion

Major differences among this modest collection of RCTs limit our attempt to fully synthesize results, leading to our uncertainty regarding overall benefits of MBIs on sleep among cancer survivors. A major dissimilarity in these trials is how researchers define sleep problems and subsequently enroll participants, ranging from low levels of sleep disturbance to a clinically defined diagnosis of insomnia. Two of the most robust and rigorously executed RCTs to date found general improvement in sleep on objective [14••] and subjective [13••] measures at 1.5 [14••] and 3-month follow-up [13••] (Table 1). However, these trials reported variable levels of baseline sleep problems, which may represent unique populations of sleepers. Participants in the Garland et al. study were required to have a clinical diagnosis of insomnia [13••]. Findings revealed large effect sizes on the ISI, PSQI, and components of the sleep diary (approximately 0.62–1.60) at follow-up [13••]. Conversely, sleep disturbance among participants in the Lengacher et al. study was not required [14••]. Findings revealed small effect sizes on actigraphy measurements (approximately 0.33–0.39) among participants with moderate sleep problems at baseline [14••]. Three out of the four RCTs that investigate sleep as a secondary outcome did not incorporate sleep-related enrollment criteria, reported low to moderate levels of baseline sleep disturbance, and found improvement in sleep scores on subjective measures at post-intervention [17••, 18••, 19••]. However, these trials yielded small effect sizes (<0.30) [17••] and failed to report significant findings at follow-up [17••, 18••]. The only RCT to demonstrate positive, long-term benefits on sleep was Garland et al.'s trial that included participants with a confirmed diagnosis of insomnia with a mean disease duration of

approximately 6 years, indicating presence of a stable, long-term sleep disorder [13••]. MBIs may have the most utility for cancer survivors with a diagnosis of insomnia, albeit we are cautious to note any further promise of efficacy without replication of results in studies that establish an insomnia diagnosis as a baseline enrollment criterion. We also observed other limitations and consider them below.

It is important to distinguish RCTs that investigate sleep as a primary versus secondary outcome, considering limitations of interpreting direct effects of MBIs on sleep associated with the latter. Trials assessing sleep as a secondary outcome have focused on intrinsically related primary conditions, including depression, anxiety, and distress; these conditions may induce a spectrum of comorbid sleep disturbances, ranging in severity and frequency depending on the presence and duration of the primary condition. For example, Bower et al. found improvement in levels of depressive symptoms and perceived stress (primary outcomes) and sleep (secondary outcome) among cancer survivors in MAPS at post-intervention [18••]. Patients suffering from stress and depressive symptoms may experience problems with sleep as a comorbid ailment. Although researchers controlled for baseline levels of the primary outcomes, it does not guarantee that improvement in sleep was a main effect of the intervention and not a byproduct of the observed improvement in perceived stress and depressive symptoms. Most trials that found improvement in sleep also found improvement in primary outcomes [16••, 18••, 19••], limiting our interpretation of efficacy for MBIs impacting sleep. One way to address this issue is to conduct statistical mediation analyses to assess whether the primary outcome acts as a mediator between MBIs and improvement in sleep.

Clinical characteristics related to baseline sleep disturbances, treatment type, and time from diagnosis varied and emphasize the need for more restrictive inclusion criteria. As mentioned earlier, lack of consistency in baseline criteria defining sleep outcomes was problematic for interpreting intervention efficacy. The majority of RCTs did not incorporate enrollment criteria related to sleep; therefore, lack of significant group differences may be attributed to negligible baseline sleep problems not prone to change [16••, 17••]. Still, three of the four trials reported low to moderate mean levels of sleep disturbances among study participants and found significant differences on sleep scores between groups at post-intervention [17••, 18••, 19••] and 1-month follow-up [19••]. However, longer-term differences between groups were not detected [17••, 18••, 19••] and may require diagnostic criteria related to the presence of sleep disturbance or disorders with utilization of clinically relevant cut-off scores. For example, insomnia medically diagnosed via the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-V), ISI score of over 14 [20], PSQI score of over 5 [15], etc. can be used to target populations with recognizable and possibly modifiable sleep problems.

Five of the six RCTs required participants to have completed cancer treatment at trial initiation; however, three RCTs allowed for continuation of certain types of treatment, including endocrine therapy [13, 18••, 19••]. Conflicting reports on the effects of endocrine therapy (or hormone therapy) on sleep have been reported in the past, including evidence that certain types, such as estrogen therapy, improve sleep, and conversely that chemotherapy and hormone therapy increase hot flashes that disrupt sleep and lead to

insomnia [21]. It is important for trialists to note the possible impact of hormone therapy on sleep and control for its effects in their study design. Bower et al. [18••] and Andersen et al. [17••] assessed number of night sweats and hot flashes experienced by the participants; however, Andersen et al. [17••] did not require participants to have completed cancer treatment prior to trial initiation. Cancer treatments have been linked to sleep problems and may interfere with the observed treatment effect if the trial is underpowered and randomization is unsuccessful. Time from cancer diagnosis varied widely among trials, and ranged from 3 months [17••] to 10 years [16••]. Length of time from diagnosis can impact psychological and social features linked with sleep (e.g., stress, life role modification, work) [22–26]. Survivors diagnosed years prior to the trial's initiation are likely not to experience similar life events/stressors that can affect sleep as those who have been recently diagnosed or just finished treatment, times when stress levels are reportedly high [22]. Although this sample diversity supports external validity, there is a cost to internal validity during the early stages of investigation. Thus, controlling bias in study design by imposing shorter diagnostic time frames among survivors is one solution.

While these RCTs utilized objective and subjective sleep measures, there are inherent limitations associated with both. Garland et al. [13••] and Lengacher et al. [14••] used wrist-worn actigraphy as their objective sleep measure in addition to validated subjective measures, demonstrating more thorough methodology. Actigraphy offers a valid and reliable cost-effective tool for assessing sleep for 24-h periods spanning multiple days, contrasting with more costly polysomnography (PSG), representing the clinical "gold standard" sleep assessment [27]. Although useful, actigraphy can overestimate sleep and underestimate wake time while the user lays quietly, and also unreliably quantifies sleep variability among clinical populations, such as insomniacs [27]. This may be a reason why cancer survivors with insomnia in Garland et al.'s trial failed to show the same improvement in sleep via actigraphy that were found in the subjective measures [13••]. Conversely, Lengacher et al. found significant improvement in actigraphy among patients with less severe sleep problems; however, these results were not corroborated by subjective measures [14••]. Studies show that as sleep efficiency decreases, actigraphy becomes less useful, and so subjective measures become more reliable in these circumstances [27]. Tailoring measures to the study population is critical especially if measures have shown limitations in assessing sleep variability among clinical groups. All RCTs assessing sleep as a secondary outcome utilized only subjective measures of sleep, including a sleep diary [16••], the MOS sleep scale [17••], the PSQI [18••], and the ISI [19••]. The MOS sleep scale does not contain formalized cut-off scores to detect sleep problems and therefore lacks clinical meaning [17••]. Bower et al. [18••] and Johns et al. [19••] incorporated clinically validated measures of sleep in their trials (PSQI and ISI) and found improvement on mean scores; however, they did not include objective measures of sleep to validate their subjective findings. Trialists should utilize both subjective and objective sleep measures that are most relevant to the sample type and incorporate PSG when possible. Past studies have tested the effects of MBIs on sleep using PSG among people with insomnia [28] and unipolar depression [29] but without cancer. Utilization of PSG represents a natural progression toward scientific rigor in the field.

Selection of control groups likely influenced trial results. The majority of trials used non-active control groups, introducing bias from the experimental method, including attention, expectation, group support, instructor(s), motivation, and other non-specific effects [13••, 14••, 17••, 18••, 19••]. Shapiro et al. used a non-structured, semi-active control group. Although participants were encouraged to engage in stress-management activities, they did not receive the same amount of support, engagement, and motivation from clinicians compared to MBSR [16••]. Garland et al. used a comparable, active control group of CBT-I [13••]. Notwithstanding obvious strengths of the trial, there are major differences between the interventions. The CBT-I curriculum imparts learning of sleep-specific behavioral strategies (sleep restriction, etc.) targeting insomnia symptoms. These strategies provide CBT-I participants motivating tools to directly combat sleep problems. Conversely, participants in the MBSR group learn how to conduct body scans, meditate while sitting and walking, and engage in gentle mindful postures to manage daily stressors, such as sleep problems. Thus, benefits related to sleep in the MBSR group likely evolved through changes inherent in the process of meditation. Perhaps, this is the reason why MBSR demonstrated statistical non-inferiority to CBT-I for sleep at only 5-month follow-up, allowing enough time for participants to cultivate their mindfulness skills [13••]. Adapting a MBSR program specifically for insomnia symptoms may be a promising approach for trialists testing the non-inferiority of MBIs to conventional sleep therapies. Generally, trialists should incorporate more comparable, active control interventions (including sham mindfulness [30]) to more convincingly reveal relative treatment efficacy.

Practice of mindfulness in daily life is an important component of MBIs and is often used as a measure of intervention dosage. Although participants were encouraged to engage in mindfulness activities at home, Garland et al. [13••] and Andersen et al. [17••] did not assess for effects of practice on sleep outcomes. Johns et al. [19••] found that 74–88% of participants engaged in mindfulness practice weekly at 6-month follow-up. Bower et al. reported that 75% of participants had meditated within the past week while 25% reported not meditating at all at 3-month follow-up [18••]. Long-term significant findings related to MBSR may be due to better adherence to mindfulness practice; however, researchers did not conduct further analyses on practice and sleep outcomes, limiting our interpretability of the results. Lengacher et al. [14••] reported no significant correlations between practice and sleep measures, while Shapiro et al. [16••] found a significant, positive interaction of informal mindfulness practice and time on sleep parameters. Nevertheless, both trials did not report specific quantification of mindfulness practice among participants for these analyses. Further investigation to determine the effects of mindfulness practice on sleep among cancer populations undergoing MBIs within the field is needed.

To conclude, our attempt to determine the benefits of MBIs on sleep among cancer survivors in these RCTs is limited due to high variability in sleep measures used and population types (ranging from intermittent sleep difficulties to chronic insomnia). Findings reveal that testing MBIs may require sleep problems of clinical magnitude at baseline to avoid ceiling effects and detect lasting changes. Cancer treatment and time from diagnosis within this population should be accounted for by implementing exclusion criteria related to treatment, restricting diagnostic time frames, and statistically controlling for these factors. Trialists should also incorporate valid subjective and objective sleep measures (such as PSG), utilize comparable

active control groups, and report dosage effects on sleep outcomes. Tackling aforementioned limitations by heeding the proposed recommendations will help improve future RCTs and better inform treatment of sleep problems among cancer survivors.

Funding/Support

Funding and resource support was received by a grant from the National Institute on Aging to the USC/UCLA Center on Biodemography and Population Health (P30AG017265), the National Center for Complementary and Integrative Health (L30AT008380), and the American Mindfulness Research Association. The ideas and opinions expressed herein are those of the author(s) and endorsement of those opinions by funders is not intended nor inferred.

References

Papers of particular interest, published recently, have been highlighted as:

•• Of major importance

1. Piet J, Wurtzen H, Zachariae R. The effect of mindfulness-based therapy on symptoms of anxiety and depression in adult cancer patients and survivors: a systematic review and meta-analysis. J Consult Clin Psychol. 2012;80(6):1007–20. [PubMed: 22563637]
2. Shennan C, Payne S, Fenlon D. What is the evidence for the use of mindfulness-based interventions in cancer care? Psychooncol. 2011;20(7):681–97.
3. Ong JC, Ulmer CS, Manber R. Improving sleep with mindfulness and acceptance: a metacognitive model of insomnia. Behav Res Ther. 2012;50(11):651–60. [PubMed: 22975073]
4. Black DS, O'Reilly GA, Olmstead R, Breen EC, Irwin MR. Mindfulness meditation and improvement in sleep quality and daytime impairment among older adults with sleep disturbances: a randomized clinical trial. JAMA Intern Med. 2015;175(4):494–501. [PubMed: 25686304]
5. Bleiker EM, Pouwer F, van der Ploeg HM, Leer JW, Ader HJ. Psychological distress two years after diagnosis of breast cancer: frequency and prediction. Patient Educ Couns. 2000;40(3):209–17. [PubMed: 10838000]
6. Davidson JR, MacLean AW, Brundage MD, Schulze K. Sleep disturbance in cancer patients. Soc Sci Med. 2002;54(9):1309–21. [PubMed: 12058848]
7. Bower JE, Ganz PA, Irwin MR, Kwan L, Breen EC, Cole SW. Inflammation and behavioral symptoms after breast cancer treatment: do fatigue, depression, and sleep disturbance share a common underlying mechanism? J Clin Oncol. 2011;29(26):3517–22. [PubMed: 21825266]
8. Liu L, Mills PJ, Rissling M, Fiorentino L, Natarajan L, Dimsdale JE, et al. Fatigue and sleep quality are associated with changes in inflammatory markers in breast cancer patients undergoing chemotherapy. Brain Behav Immun. 2012;26(5):706–13. [PubMed: 22406004]
9. Rouleau CR, Garland SN, Carlson LE. The impact of mindfulness-based interventions on symptom burden, positive psychological outcomes, and biomarkers in cancer patients. Cancer Manag Res. 2015;7:121–31. [PubMed: 26064068]
10. Palesh OG, Roscoe JA, Mustian KM, Roth T, Savard J, Ancoli-Israel S, et al. Prevalence, demographics, and psychological associations of sleep disruption in patients with cancer: University of Rochester Cancer Center-Community Clinical Oncology Program. J Clin Oncol. 2010;28(2):292–8. [PubMed: 19933917]
11. Harrington CB, Hansen JA, Moskowitz M, Todd BL, Feuerstein M. It's not over when it's over: long-term symptoms in cancer survivors—a systematic review. Int J Psychiatry Med. 2010;40(2):163–81. [PubMed: 20848873]
12. NIH National Cancer Institute. NCI Dictionary of Cancer Terms [Available from: https://www.cancer.gov/publications/dictionaries/cancer-terms?CdrID=450125].
13••. Garland SN, Carlson LE, Stephens AJ, Antle MC, Samuels C, Campbell TS. Mindfulness-based stress reduction compared with cognitive behavioral therapy for the treatment of insomnia comorbid with cancer: a randomized, partially blinded, noninferiority trial. J Clin Oncol.

2014;32(5):449–57. [PubMed: 24395850] Main focus in our critical examination of RCTs targeting sleep problems. A rigerously executed RCT focusing on sleep as a primary outcome among cancer survivors with a confirmed diagnosis of insomnia, utilizing both ojective and subjective sleep measures.

14••. Lengacher CA, Reich RR, Paterson CL, Jim HS, Ramesar S, Alinat CB, et al. The effects of mindfulness-based stress reduction on objective and subjective sleep parameters in women with breast cancer: a randomized controlled trial. Psychooncology. 2015;24(4):424–32. [PubMed: 24943918] Main focus in our critical examination of RCTs targeting sleep problems among cancer survivors. A rigerously executed RCT focusing on sleep as a secondary outcome, utilizing both ojective and subjective sleep measures.

15. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res. 1989;28(2):193–213. [PubMed: 2748771]

16••. Shapiro SL, Bootzin RR, Figueredo AJ, Lopez AM, Schwartz GE. The efficacy of mindfulness-based stress reduction in the treatment of sleep disturbance in women with breast cancer: an exploratory study. J Psychosom Res. 2003;54(1):85–91. [PubMed: 12505559] Main focus in our critical examination on RCTs targeting sleep problems among cancer survivors. RCT focusing on sleep as a secondary outcome among cancer survivors utilizing subjective measures of sleep.

17••. Andersen SR, Wurtzen H, Steding-Jessen M, Christensen J, Andersen KK, Flyger H, et al. Effect of mindfulness-based stress reduction on sleep quality: results of a randomized trial among Danish breast cancer patients. Acta Oncol. 2013;52(2):336–44. [PubMed: 23282113] Main focus in our critical examination of RCTs targeting sleep problems among cancer survivors. RCT focusing on sleep as a secondary outcome among cancer survivors utilizing subjective measures of sleep.

18••. Bower JE, Crosswell AD, Stanton AL, Crespi CM, Winston D, Arevalo J, et al. Mindfulness meditation for younger breast cancer survivors: a randomized controlled trial. Cancer. 2015;121(8): 1231–40. [PubMed: 25537522] Main focus in our critical examination of RCTs targeting sleep problems among cancer survivors. RCT focusing on sleep as a secondary outcome among cancer survivors utilizing a subjective measure of sleep.

19••. Johns SA, Brown LF, Beck-Coon K, Monahan PO, Tong Y, Kroenke K. Randomized controlled pilot study of mindfulness-based stress reduction for persistently fatigued cancer survivors. Psychooncology. 2015;24(8):885–93. [PubMed: 25132206] Main focus in our critical examination of RCTs targeting sleep problems among cancer survivors. RCT focusing on sleep as a secondary outcome among cancer survivors utilizing a subjective measure of sleep.

20. Gagnon C, Belanger L, Ivers H, Morin CM. Validation of the Insomnia Severity Index in primary care. J Am Board Fam Med. 2013;26(6):701–10. [PubMed: 24204066]

21. Savard J, Simard S, Blanchet J, Ivers H, Morin CM. Prevalence, clinical characteristics, and risk factors for insomnia in the context of breast cancer. Sleep. 2001;24(5):583–90. [PubMed: 11480655]

22. Shapiro SL, Lopez AM, Schwartz GE, Bootzin R, Figueredo AJ, Braden CJ, et al. Quality of life and breast cancer: relationship to psychosocial variables. J Clin Psychol. 2001;57(4):501–19. [PubMed: 11255204]

23. Montazeri A, Vahdaninia M, Harirchi I, Ebrahimi M, Khaleghi F, Jarvandi S. Quality of life in patients with breast cancer before and after diagnosis: an eighteen months follow-up study. BMC Cancer. 2008;8:330. [PubMed: 19014435]

24. Johnsson A, Fornander T, Rutqvist LE, Olsson M. Work status and life changes in the first year after breast cancer diagnosis. Work. 2011;38(4):337–46. [PubMed: 21508523]

25. Hartl K, Engel J, Herschbach P, Reinecker H, Sommer H, Friese K. Personality traits and psychosocial stress: quality of life over 2 years following breast cancer diagnosis and psychological impact factors. Psychooncology. 2010;19(2):160–9. [PubMed: 19189279]

26. Kangas M, Henry JL, Bryant RA. The course of psychological disorders in the 1st year after cancer diagnosis. J Consult Clin Psychol. 2005;73(4):763–8. [PubMed: 16173866]

27. Ancoli-Israel S, Cole R, Alessi C, Chambers M, Moorcroft W, Pollak CP. The role of actigraphy in the study of sleep and circadian rhythms. Sleep. 2003;26(3):342–92. [PubMed: 12749557]

28. Ong JC, Manber R, Segal Z, Xia Y, Shapiro S, Wyatt JK. A randomized controlled trial of mindfulness meditation for chronic insomnia. Sleep. 2014;37(9):1553–63. [PubMed: 25142566]

29. Britton WB, Haynes PL, Fridel KW, Bootzin RR. Mindfulness-based cognitive therapy improves polysomnographic and subjective sleep profiles in antidepressant users with sleep complaints. Psychother Psychosom. 2012;81(5):296–304. [PubMed: 22832540]

30. Zeidan F, Emerson NM, Farris SR, Ray JN, Jung Y, McHaffie JG, et al. Mindfulness meditation-based pain relief employs different neural mechanisms than placebo and sham mindfulness meditation-induced analgesia. J Neurosci. 2015;35(46):15307–25. [PubMed: 26586819]

Table 1

Overview of RCTs examining the effects of MBIs on sleep outcomes among cancer survivors

Study	Sample size, sex, stage/ type of cancer	Sleep endpoint type	Subjective plus objective sleep measure	Sleep is a screening criteria for enrollment	Cancer screening criteria for enrollment	Level of sleep problems at baseline	MBI	Control	Significant improvement at immediate post-intervention (Cohen's *d)*	Significant improvement at follow-up (Cohen's *d)*
Lengacher et al. (2015) [14••]	*N* = 79 W, stage 0–III breast cancer	Primary	Yes	No	In treatment	Moderate	MBSR	Usual care	No (not reported)	Wrist-worn actigraphy: SE% (0.33), number of waking bouts (0.38) at 1.5 months
Garland et al. (2014) [13••]	*N* = 111 (80 W, 31 M), breast (48%), prostate (11%)	Primary	Yes	Yes (Insomnia)	In treatment	High	MBSR	CBT-I	ISI (1.39); PSQI (0.62), sleep diary: SOL (0.29), WASO (0.89), TST (0.22), SE% (0.62)	ISI (1.52); PSQI (1.04); sleep diary: SOL (0.78), WASO (1.04), TST (0.95), SE% (0.94) at 3 months
Johns et al. (2015) [19••]	*N* = 35 (33 W, 2 M), stage 0–III breast (85 J %); hematologic (11%)	Secondary	No	No	In treatment (excluding hormone therapy)	Moderate	MBSR	Wait-list	ISI(0.74)	ISI (1.00) at 1 month
Bower et al. (2015) [18••]	*N* = 71 W, stage 0–III breast	Secondary	No	No	In treatment (excluding hormone therapy)	Moderate	MAPs	Wait-list	PSQI (not reported)	No
Andersen et al. (2013) [17••]	*N* = 336 W, stage I–III breast	Secondary	No	No	None	Low	MBSR	Usual Care	SPI-I (not reported); SPI-II (0.24); MOS sleep disturbance (not reported)	No
Shapiro et al. (2003) [16••]	*N* = 63 W, stage II breast	Secondary	No	No	In treatment	Low-Moderate	MBSR	Free-choice	No (not reported)	No

Notes. *W* women, *M* men, *MBI* mindfulness-based intervention, *MBSR* mindfulness-based stress reduction, *MAPs* mindful awareness practices, *CBT-I* Cognitive Behavioral Therapy for Insomnia, *SE* sleep efficiency, *ISI* Insomnia Severity Index, *PSQI* Pittsburgh Sleep Quality Index, *SOL* sleep onset latency, *WASO* wake after sleep onset, *TST* total time sleeping, *SPI-I* Sleep Problem Index I, *SPI-II* Sleep Problem Index II, *MOS* Medical Outcome Study sleep scale