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Mindfulness-Based Interventions for Insomnia: A Meta-Analysis of Randomized Controlled Trials

Yuan-Yuan Wang*, Fei Wangb*, Wei Zhenga*, Ling Zhanga*, Chee H. Ng, Gabor S. Ungvarif, and Yu-Tao Xianga

aFaculty of Health Sciences, University of Macau, Macao SAR, China; bGuangdong Mental Health Center, Guangdong General Hospital & Guangdong Academy of Medical Sciences, Guangzhou, China; cThe Affiliated Brain Hospital of Guangzhou Medical University (Guangzhou Huiai Hospital), Guangzhou, Guangdong, China; dThe National Clinical Research Center for Mental Disorders, China & Center of Depression, Beijing Institute for Brain Disorders & Mood Disorders Center, Beijing Anding Hospital, Capital Medical University, Beijing, China; eDepartment of Psychiatry, University of Melbourne, Melbourne, Victoria, Australia; fUniversity of Notre Dame Australia/Graylands Hospital, Perth, Australia

ABSTRACT

Objective: Mindfulness-based interventions (MBIs) are clinically effective for insomnia, but the research findings have been mixed. This meta-analysis of randomized controlled trials (RCTs) examined the effect of MBIs on insomnia.

Method: Both English (PubMed, PsycINFO, Embase, and Cochrane Library databases) and Chinese (WanFang and CNKI) databases were systematically and independently searched. Standardized mean differences (SMDs) and risk ratio (RR) with their 95% confidence intervals (CIs) were calculated using the random effects model.

Results: Five RCTs (n = 520) comparing MBIs (n = 279) and control (n = 241) groups were identified and analyzed. Compared to the control group, participants in the MBIs group showed significant improvement in insomnia as measured by the Pittsburgh Sleep Quality Index (n = 247; SMD: −1.01, 95% CI: −1.28 to −0.75, I^2 = 0%, p < 0.00001) at post-MBIs assessment.

Conclusion: In this comprehensive meta-analysis, MBIs appear to be effective in the treatment of insomnia. Further studies to examine the long-term effects of MBIs for insomnia are needed.

Insomnia is a common sleep disorder that is associated with increased risk of physical comorbidities, psychiatric disorders, impaired social function (Gong et al., 2016; Li et al., 2015; Ohayon & Bader, 2010), and all-cause mortality (Araujo et al., 2017). Insomnia has been estimated to affect up to a third of the population globally based on different diagnoses (Ohayon, 2002). Common strategies for treating insomnia include pharmacotherapy and psychosocial interventions, such as cognitive behavioral therapy (CBT) and mindfulness-based interventions (MBIs). Both pharmacotherapy and psychosocial interventions are widely used to treat insomnia (Hohagen et al., 1994). CBT has been regarded as a first-line treatment for chronic insomnia in many countries (Perlis & Smith, 2008), with satisfactory effectiveness (Cheng & Dizon, 2012; Wang, Wang, & Tsai, 2005).

Mindfulness-based interventions (MBIs) are often used in treating insomnia (Wong et al., 2017; Zhang et al., 2015) and could improve insomnia and sleep quality (Black, O’Reilly, Olmstead, Breen, & Irwin, 2015; Bowden, Gaudry, An, & Gruzelier, 2012; Crain, Schonert-Reichl, & Roeser, 2017; Rao, Metri, Raghubram, & Hongasandra, 2017; Wong et al., 2017).

CONTACT Yu-Tao Xiang xyutly@gmail.com 3/F, Building E12, Faculty of Health Sciences, University of Macau, Avenida da Universidade, Taipa, Macau SAR, China.

*These authors contributed equally to the work. Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/hbsm.
Mindfulness emphasizes the awareness that emerges through purposeful attention to the present moment, with an accepting and nonjudgmental attitude (Kabat-Zinn, 2003). MBIs aim to reduce worry about the past or the future, and focus on everyday activities (Kanen, Nazir, Sedky, & Pradhan, 2015). MBIs consist of a number of brief interventions that incorporate mindfulness as a principle (Strauss, Cavanagh, Oliver, & Pettman, 2014), including the Mindfulness-Based Cognitive Therapy (MBCT), Mindfulness-Based Stress Reduction (MBSR) and other approaches with modified or integrated mindfulness components. Of them, MBCT and MBSR are the most widely used in treating psychiatric disorders and related problems (Strauss et al., 2014). MBSR was developed from the ancient tradition of mindfulness meditation established by Kabat-Zinn et al in 1970s, and was used as a method of healing (Kabat-Zinn, 2003). In contrast, MBCT was developed in the 1990s by integrating MBSR with cognitive therapy elements, which is now used in the maintenance treatment for depression and insomnia (Kuyken et al., 2016; Segal, Williams, & Teasdale, 2012; Wong et al., 2017). Studies of insomnia treatments have compared MBIs and pharmacotherapy (Gross et al., 2011; Cohen’s d = −0.64 in sleep efficiency), CBT and pharmacotherapy (Jacobs, Pace-Schott, Stickgold, & Otto, 2004; Cohen’s d = 1.1 in sleep efficiency), and MBIs and CBT (Garland et al., 2014; Cohen’s d = −2.76 in sleep efficiency), but the findings have been mixed.

Several meta-analyses (Gong et al., 2016; Kanen et al., 2015) were conducted to examine the effect of MBIs on sleep problems, but studies involving subjects with major medical conditions, such as cancer and osteoarthritis, were not excluded. Major medical conditions, including physical and psychiatric comorbidities and medication-caused side effects, could influence the effect of MBIs on insomnia and limit the generalizability of the findings (O’Donnell, 2004). In addition, several recent RCTs of MBIs have been published and not been included in previous meta-analyses (Wei et al., 2017; Wong et al., 2017). Thus, we performed a comprehensive meta-analysis of RCTs on MBIs for insomnia. We hypothesized that compared to control groups, MBIs would be more effective for improving insomnia.

Methods
Selection criteria
According to the PICOS acronym, the following inclusion criteria were used: Participants (P): participants with insomnia according to standardized diagnostic criteria, such as the Chinese Classification and Diagnostic Criteria for Mental Disorders, third edition (CCMD-3; Chen, 2002), the Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV; American Psychiatric Association, 1994), and the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10; World Health Organization, 1992). Intervention (I): MBIs group including MBIs alone or MBIs plus other treatments (e.g., health education). Comparison (C): control group; that is, receiving other intervention (i.e., pharmacotherapy or sleep hygiene education) and blank control or waitlist control. Outcomes (O): the primary outcome measure was insomnia at post-MBI assessment as measured using standardized rating scales, such as the Pittsburgh Sleep Quality Index (PSQI) (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). Key secondary outcome measures included other sleep-related data, such as sleep efficacy, total sleep time, total wake time, and sleep quality. Study design (S): RCTs with meta-analyzable data. Case reports or series, qualitative reports, observational trials, nonrandomized studies, reviews, and meta-analyses were excluded. Studies conducted in patients with major medical conditions (e.g., cancer) were excluded.

Search methods
Both English (PubMed, PsycINFO, Embase, and Cochrane Library databases) and Chinese (WanFang, and CNKI) databases were systematically and independently searched by two
reviewers (YYW and FW), from their inception until August 16, 2017. The following search terms were used: (“insomnia” OR “sleep” OR “early morning awakening” OR “maintenance disorder” OR “dyssomnia” OR “sleepless”) AND (“mindfulness” OR “Mindfulness-Based Cognitive Therapy” OR “Mindfulness-Based Stress Reduction” OR “MBCT” OR “MBSR”) AND (“Random*” OR “control” OR “Randomized controlled trial”). Moreover, reference lists of the relevant reviews were hand-searched in order to avoid missing studies.

**Data extraction**

Two reviewers (YYW and FW) independently extracted the relevant data. Any inconsistency arising in the process was discussed to reach an agreement or was resolved by referring to a third reviewer (YTX). Two studies reported both actigraphy and sleep diary data (Gross et al., 2011; Ong et al., 2014); in order to avoid interdependence, only actigraphy data were extracted. There was one study (Ong et al., 2014) with three treatment arms that compared the control group with two different MBIs groups. Half of the participants in the control group were assigned to each MBIs arm to avoid inflating the number of participants in the control group.

**Quality assessment**

The quality of the included studies were assessed by the Cochrane risk of bias (Higgins & Green, 2014) and Jadad scale (Jadad et al., 1996), both of which are widely used quality assessment tools for meta-analyses of RCTs. The Cochrane risk of bias assesses the aspects of selection bias (random sequence generation and allocation concealment), reporting bias (selective reporting), blinding, attribution bias, and other sources of bias; while the Jadad scale assesses the randomization, blinding, and withdrawals and dropouts of participants with the total score ranging from 3 to 4. Jadad total score < 3 was rated as low-quality; otherwise, it was considered as high-quality (Jadad et al., 1996). The grading of recommendations assessment, development, and evaluation (GRADE) system (Atkins et al., 2004; Balshem et al., 2011) was used to judge the evidence level of outcomes.

**Data synthesis and statistical analyses**

The Review Manager Version 5.3 (http://www.cochrane.org) and Comprehensive Meta-Analysis V2.0 (www.meta-analysis.com) were used to synthesize data and conduct additional analyses. Considering the discrepancies in sampling methods, measurements, and demographic characteristics between studies, the random effects model was used in all meta-analytic outcomes because it is more conservative than the fixed-effects model (DerSimonian & Laird, 1986). Standardized mean difference (SMD) with 95% confidence intervals (CIs) was used for continuous outcomes. Risk ratio (RR) ± 95% CI was calculated for dichotomous data. Study heterogeneity was measured using $I^2$, with $I^2$ values greater than 50% indicating significant heterogeneity (Higgins, Thompson, Deeks, & Altman, 2003). All meta-analytic outcomes were two-tailed, with significance level set at 0.05.

**Results**

**Literature search and study characteristics**

A total of 527 relevant hits were identified in the initial search. As shown in Figure 1, 5 RCTs with 11 MBT treatment arms were included in the analyses. In Table 1, the pooled sample size was 520, with 279 patients in the MBIs group and 241 in the control group. Study sites included China (3 RCTs, $n = 436$), the United States (2 RCTs, $n = 84$). The MBIs treatment duration ranged from 6 to 8 weeks. One study in China used the CCMD-3 (Psychiatry Branch of the Chinese Medical
Association, 2001), one study in China used DSM-IV (American Psychiatric Association, 1994), another study in Hong Kong used both DSM-IV (American Psychiatric Association, 1994) and ICD-10 (World Health Organization, 1992), and two U.S. studies used DSM-IV (American Psychiatric Association, 1994) and DSM-IV-TR (American Psychiatric Association, 2000). MBIs treatment frequency varied from 50 min per week for 6 weeks, to 2.5 hr per day for 8 weeks.

**Assessment quality and quality of evidence**

The risk of bias of the included studies is summarized in Supplemental Figure 1. Two RCTs were single blinded and all the others did not report blinding. Five RCTs described the random allocation sequence generation, and none mentioned allocation concealment. All studies were rated as low-risk in terms of attrition and reporting bias. Jadad scores ranged from 3 to 4 (Table 1). Of the 5 RCTs, all were rated as high-quality. The quality of evidence of 5 outcome measures ranged from low-quality (80%) to moderate-quality (20%) according to the GRADE approach (Table 2).

Figure 1. PRISMA flow diagram.
### Table 1. Characteristics of included RCTs.

<table>
<thead>
<tr>
<th>First Author (country)</th>
<th>n (^a)</th>
<th>M (%) (^a)</th>
<th>Age (y) (^a)</th>
<th>Diagnostic criteria</th>
<th>Type of MBIs</th>
<th>Duration (wks)</th>
<th>Type of interventions; n</th>
<th>Frequency of MBIs</th>
<th>Follow-up time</th>
<th>Outcomes (Sleep measures)</th>
<th>Dropout rate (MBIs, %)</th>
<th>Jadad score (^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wei 2017, China (Wei et al., 2017)</td>
<td>160</td>
<td>43; 69/160</td>
<td>57.7</td>
<td>CCMD-3</td>
<td>MBSR</td>
<td>6</td>
<td>1. MBSR + regular health education; n = 80 2. Regular health education; n = 80</td>
<td>50 min/wk 6×/wk</td>
<td>NR</td>
<td>PSQI</td>
<td>0; 0/80</td>
<td>3</td>
</tr>
<tr>
<td>Gross 2011, US (Gross et al., 2011)</td>
<td>30</td>
<td>27; 8/30</td>
<td>NR</td>
<td>DSM-IV-TR</td>
<td>MBSR</td>
<td>8</td>
<td>1. MBSR; n = 20 2. pharmacotherapy; n = 10</td>
<td>2.5 h class/wk + 45 min practice at least 6 days a week, 8×/wk (+ a day-long retreat)</td>
<td>3 month</td>
<td>PSQI; actigraphy (TST &amp; SE)</td>
<td>5; 1/20</td>
<td>3</td>
</tr>
<tr>
<td>Ong 2014, US (Ong et al., 2014)</td>
<td>54</td>
<td>26; 9/35</td>
<td>43.77</td>
<td>DSM-IV</td>
<td>MBSR &amp; MBTI</td>
<td>8</td>
<td>1. MBSR; n = 19 2. MBTI; n = 19 3. Self-monitoring (SM) condition; n = 16</td>
<td>2.5 h/d, 8×/wk (+ one 6-h retreat)</td>
<td>3 &amp; 6 months (^b)</td>
<td>actigraphy (TWT, TST, SE)</td>
<td>MBSR: 21; 4/19; MBTI: 0; 0/19</td>
<td>3</td>
</tr>
<tr>
<td>Wong 2017, China (HK) (Wong et al., 2017)</td>
<td>216</td>
<td>22; 47/216</td>
<td>56.1</td>
<td>DSM-IV and ICD-10 combined</td>
<td>MBCT</td>
<td>8</td>
<td>1. MBCT; n = 111 2. Sleep psycho-education with exercise control (PEEC); n = 105</td>
<td>2.5 h/d, 8×/wk</td>
<td>3 &amp; 6 months</td>
<td>Insomnia severity Index; sleep diary (TST &amp; SE)</td>
<td>18; 18/101</td>
<td>4</td>
</tr>
<tr>
<td>Zhang 2015, China (Zhang et al., 2015)</td>
<td>60</td>
<td>58; 35/60</td>
<td>78.1</td>
<td>DSM-IV</td>
<td>MBSR</td>
<td>8</td>
<td>1. MBSR; n = 30 2. wait-list control; n = 30</td>
<td>45 min/d, 8×/wk</td>
<td>NR</td>
<td>PSQI</td>
<td>3; 1/30</td>
<td>4</td>
</tr>
</tbody>
</table>

Note. \(^a\)The sample size was derived at the randomization assessment; gender proportion and age were derived from extractable information.  
\(^b\)Only 6 months of data were available for actigraphy.  
\(^c\)Jadad total score < 3 was rated as low-quality; otherwise, it was considered as high-quality.

Abbreviations: CCMD-3, Chinese Classification and Diagnostic Criteria for Mental Disorders, third edition; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, fourth edition; DSM-IV-TR, Diagnostic and Statistical Manual of Mental Disorders, fourth edition, text revision; d, day; ICD-10, the International Statistical Classification of Diseases and Related Health Problems, 10th revision; M, male; min, minute; MBI, Mindfulness-Based Intervention; MBCT, Mindfulness-Based Cognitive Therapy; MBSR, Mindfulness-Based Stress Reduction; MBTI, Mindfulness-Based Therapy for Insomnia; PSQI, Pittsburgh Sleep Quality Index; n, number of patients; NR, not report; SE, sleep efficiency; TST, total sleep time; TWT, total wake time; wk, week.
Insomnia assessed by PSQI at post-MBI assessment

Three RCTs with 3 treatment arms reported data on insomnia assessed by the PSQI at the post-MBIs assessment. Compared to the control group, the MBIs group showed significant improvement in post-MBIs insomnia ($n = 247$; SMD: $-1.01$, 95% CI: $-1.28$ to $-0.75$, $I^2 = 0\%$, $p < 0.00001$, Figure 2).

Sleep efficiency at post-MBIs assessment

Three RCTs with 4 treatment arms provided data on sleep efficiency, with 3 arms using actigraphy (Gross et al., 2011; Ong et al., 2014), and 1 arm using sleep diary (Wong et al., 2017). There was no significant group difference in terms of sleep efficiency at post-MBIs assessment ($n = 274$; SMD: $-0.07$, 95% CI: $-0.31$ to $0.17$, $I^2 = 0\%$, $p = 0.58$).

Sleep time at post-MBIs assessment

Three RCTs with 4 treatment arms reported data on total sleep time (TST), with 3 arms using actigraphy (Gross et al., 2011; Ong et al., 2014), and 1 arm using sleep diary (Wong et al., 2017). There was no significant group difference in terms of total sleep time at post-MBIs assessment ($n = 274$; SMD: $-0.14$, 95% CI: $-0.51$ to $0.24$, $I^2 = 29\%$, $p = 0.47$). One RCT with 2 treatment arms also reported total wake time at post-MBIs using actigraphy (Ong et al., 2014), and there was no significant group difference in terms of total wake time at post-MBIs assessment ($n = 54$; SMD: $0.03$, 95% CI: $-0.55$ to $0.61$, $I^2 = 0\%$, $p = 0.92$).

Table 2. GRADE analyses.

<table>
<thead>
<tr>
<th>Primary/secondary outcome</th>
<th>Study arms (N)</th>
<th>Risk of bias</th>
<th>Inconsistency</th>
<th>Indirectness</th>
<th>Imprecision</th>
<th>Publication bias</th>
<th>Large effect</th>
<th>Overall quality of evidence$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pittsburgh Sleep Quality Index</td>
<td>3 (247)</td>
<td>Serious$^b$</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Serious$^c$</td>
<td>No</td>
<td>+/±/-/+; Low</td>
</tr>
<tr>
<td>Sleep Efficacy</td>
<td>4 (274)</td>
<td>Serious$^b$</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Serious$^c$</td>
<td>No</td>
<td>+/+/-/+; Low</td>
</tr>
<tr>
<td>Total Sleep Time</td>
<td>4 (274)</td>
<td>Serious$^b$</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Serious$^c$</td>
<td>No</td>
<td>+/+/-/+; Low</td>
</tr>
<tr>
<td>Total Wake Time</td>
<td>2 (54)</td>
<td>Serious$^b$</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Serious$^c$</td>
<td>No</td>
<td>+/+/-/+; Low</td>
</tr>
<tr>
<td>Discontinuation rate</td>
<td>6 (536)</td>
<td>Serious$^b$</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>+/+/-/+; Moderate</td>
</tr>
</tbody>
</table>

Note. GRADE = grading of recommendations assessment, development, and evaluation.
$^a$GRADE Working Group grades of evidence: High-quality = further research is very unlikely to change our confidence in the estimate of effect. Moderate-quality = further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate. Low-quality = further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate. Very low-quality = we are very uncertain about the estimate.
$^b$Meta-analytic studies (more than 50%) were open label studies or only mentioned random allocation without describing the method.
$^c$For continuous outcomes, $N < 400$. For dichotomous outcomes, $N < 300$. 

Figure 2. Effect of MBIs on PSQI at post-MBIs assessment.
All cause discontinuation

The discontinuation rate was not significantly different between the MBIs and control groups (n = 536, RR = 3.74, 95% CI: 0.74 to 18.90, I^2 = 35%, p = 0.11). Only 5 RCTs with 6 treatment arms were included for primary and secondary outcomes, thus we cannot assess publication bias by performing a funnel plot or Egger’s test (Egger, Davey Smith, Schneider, & Minder, 1997).

Discussion

This updated and comprehensive meta-analysis of RCTs on the effect of MBIs on insomnia found that MBIs significantly improved insomnia symptoms, as measured by the PSQI, compared to control groups. In addition, the discontinuation rate was not different between the MBIs and control groups, which indicates that the treatment adherence to MBIs was satisfactory.

Several meta-analyses have examined the effect of MBIs on sleep. One meta-analysis (Kanen et al., 2015) evaluated the effect of MBIs on sleep disturbances in the general population. Two earlier meta-analyses included participants with major medical conditions, such as cancer and osteoarthritis (Gong et al., 2016; Kanen et al., 2015). In order to increase the homogeneity of included studies, we excluded studies that included participants with major medical conditions and only synthesized studies that used insomnia diagnostic criteria. In addition, we included recently published RCTs in both English and Chinese databases that were not previously included. Similar to an earlier meta-analysis (Gong et al., 2016), we found that MBIs could significantly improve insomnia symptoms measured by the PSQI. The mechanism of the therapeutic effects of MBIs on insomnia is not clear, although it is recognized that MBIs could improve emotional regulation and reduce stress level (Zhang et al., 2015), which could in turn alleviate insomnia. Furthermore, another meta-analysis (Kanen et al., 2015) reported that the significant effects of MBIs on insomnia were found only in subjective (i.e., the PSQI) but not in objective assessments (i.e., actigraphy). In this study, no significant group difference was found in terms of actigraphy data as well as sleep efficacy and sleep time at the post-MBIs. Instead of assessing individual sleep parameters, the PSQI covers multiple aspects of sleep including sleep efficacy, sleep time, sleep latency, and daytime dysfunction, which therefore may be more sensitive in detecting the minor changes in insomnia symptoms.

The advantages of this meta-analysis are the inclusion of recently published RCTs (Wei et al., 2017; Wong et al., 2017) and the exclusion of those involving major medical conditions, which provide a more homogeneous sample and avoid the confounding effects caused by major medical conditions. However, there are also several methodological limitations. First, the duration and frequency of MBIs varied across studies; the dose-response of MBIs for insomnia was thus difficult to measure. Second, the follow-up period ranged from 3 to 6 months, but insufficient data were available to analyze the long-term MBIs effect on insomnia. Third, both the MBIs and control groups were heterogeneous: the MBIs groups included MBCT, MBSR, and mindfulness-based therapy for insomnia, while the control groups included wait-list control, pharmacotherapy, self-monitoring condition and regular health education, all of which increased the heterogeneity of the outcomes. Fourth, although all included studies were rated as high-quality, the quality of evidence of 5 outcome measures ranged from low-quality (80%) to moderate-quality (20%) according to the GRADE approach. Fifth, three of the five included studies were from China and two from the United States, which limits the generalization of the findings to other populations. Finally, the MBIs group included MBIs alone or MBIs plus other treatments. Other treatments, such as health education, may have augmentation effect and bias the efficacy of MBIs in insomnia.

Conclusions

This comprehensive meta-analysis of RCTs on MBIs for insomnia found that MBIs appear to have a positive effect on insomnia as measured by the PSQI. Further RCTs with larger samples and longer follow-up are needed to confirm the findings.
Acknowledgments

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Conflict of interest

We declare that the authors have no competing interests.

Statement

All co-authors have seen and approved the manuscript. There is no conflict of interest concerning the authors in conducting this study and preparing the manuscript.

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