Exploring the Evidence for the Effectiveness of Mindfulness as Treatment Approach for Sleep Disturbance: A Systematic Literature Review

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Abstract

Sleep disturbances are becoming more and more prevalent. Due to the rising number of people suffering from insomnia and related symptoms, it is important to develop and identify effective treatments. Currently, cognitive behavioral therapy for insomnia (CBT-I) is the standard treatment for insomnia, but new treatment approaches show promising outcomes as well. Mindfulness-based treatments have been developed in the past years as an adjunct to classical CBT-I or even as stand-alone interventions. This paper aims to gather and evaluate current evidence for the effectiveness of mindfulness-based treatments as well as to summarize the theoretical foundations of the mechanisms by which mindfulness can improve sleep.

To find relevant literature, the online databases Scopus, PubMed and PsycINFO have been thoroughly searched. Finally, nine papers were identified that fit the scope of this research. Study and participant characteristics, outcomes and data about effectiveness were extracted. Additionally, the mechanisms by which the effect of mindfulness of sleep were explained were extracted and summarized.

Overall, mindfulness-based interventions showed promising results in reducing insomnia severity and increasing sleep quality, especially when compared to usual care or waitlist control groups. Three mechanisms have been identified by which the effect of mindfulness on sleep is explained: Reduction of arousal, reduction of dysfunctional beliefs about sleep and increase in nonreactivity.

This literature review suggests that mindfulness can be an effective approach in treating insomnia symptoms. Further investigation of the working mechanisms is necessary to identify possible advantages and disadvantages when compared with the standard treatment. Implemented correctly, mindfulness can be a valuable adjunct to the current treatment landscape of insomnia.

Introduction

Why is sleep so important? It has been acknowledged as one of the fundamental biological processes that are crucial to our survival (Grandner, 2017). Sleep does not only restore our physical energy, but it also restores our mental capacity and functioning (Grandner, 2017). Unfortunately, the prevalence of sleep disorders is on the rise, becoming one of the most prevalent health issues in modern society (Abrams, 2021). Especially since the Covid-pandemic, researchers have observed a surge in sleep disorders and changes in sleep-related behavior (Abrams, 2021). With that in mind, it must be noted that the impact of poor sleep extends far beyond feelings of tiredness and discomfort. A lack of sleep has already been proven to be a contributing factor in the development of chronic illnesses like cancer or cardiovascular disease, as well as impairing the immune system and important cognitive functions (Rusch et al., 2019; Winbush et al, 2007). Furthermore, insomnia and insomnia symptoms can lead to reduced social and occupational functioning and quality of life (Winbush et al., 2007; Kim et al., 2020). Not only the physiological but also the psychological consequences of insomnia symptoms can be tremendous. Notably, insomnia symptoms are often comorbid with mental health conditions such as depression and anxiety (Winbush et al., 2007). It has already been recognized as one of the most common transdiagnostic symptoms across a wide range of DSM-5 classifications (Winbush et al., 2007).

What are sleep disorders? The landscape of sleep disorders is broad, comprehending phenomena such as lack of sleep, too much sleep, nightmares, breathing problems, sleepwalking, snoring or sleep paralysis (Sateia, 2004). The term refers to a number of conditions that have an impact on sleep quality and duration, and consequently interfere with the daily functioning of affected individuals (Sateia, 2004). Whereas some sleep disorders, such as sleep apnea, are primarily influenced by physiological factors (Young et al., 2004), other sleep disorders, with insomnia being the most prevalent one, arise mostly as consequences of psychological distress and maladaptive coping behavior (Sateia, 2014). Despite the mostly behavioral origins, medical issues like cancer or chronic pain can also contribute to the development of insomnia without being the physiological cause (Sateia, 2014). Generally speaking, sleep disorders are multifactorial, and can arise out of biological, cognitive or behavioral dispositions (Winbush et al., 2007). For the purpose of this review, this paper focuses on insomnia and insomnia symptoms. To this day, a lot is still unknown about the classification of sleep disorders, especially about the clinical significance of associated

symptoms (Sateia, 2014). Therefore, this paper aims to include also sub-threshold populations that do not meet current diagnostic criteria for insomnia or other sleep disorders.

Apart from medical and physiological reasons, there are multiple possible reasons for individuals to develop insomnia and related symptoms. Stress and worry are among the most common reasons to experience sleep disturbance (Riemann et al., 2017). Relationships, losses, work-related stress, or financial concerns can impact sleep enormously (Riemann et al., 2017). Unhelpful metacognitions about sleep, which are commonly prevalent in patients diagnosed with insomnia, can even worsen the symptoms (Ong et al., 2012). These cognitions are focused on and revolve around sleep itself. Patients may find themselves lying awake at night, actively trying to fall asleep due to the perceived need for it, therefore preventing sleep from occurring, as forcing oneself to sleep can lead to the exact opposite, being more alert and focused. This is associated with hyperarousal, which is an increased activation of the sympathetic nervous system (Lundh & Broman, 2000). Both physiological and cognitive arousal are thought to interfere with sleep (Ong et al., 2012). Physical activity, especially exercise, is one of the main ways our body can deal with stress, but also various techniques have been shown to decrease muscle tension and arousal, as progressive muscle relaxation (PMR) demonstrates (Low et al. 2020). Before developing effective and efficient interventions to target sleep, it is therefore important to test empirically which mechanisms are addressed by which intervention. By doing so, interventions can be tailored to the individual patient's needs.

In Europe's current treatment landscape for insomnia, cognitive behavior therapy for insomnia (CBT-I) is the preferred and strongest recommended treatment to this date (Erdinger et al, 2021a, Riemann et al., 2017). CBT-I is a multicomponent intervention that makes use of cognitive techniques, such as cognitive restructuring, and behavioral techniques such as sleep restriction, sleep hygiene, and stimulus control (Edinger et al., 2021a; Riemann et al., 2017). Alternative, more conditionally bound treatments entail single components of CBT-I and brief therapy for insomnia (BTI) (Edinger et al., 2021a), as well as pharmacotherapy and light exposure therapy and exercise (Riemann et al., 2017). A meta-analysis of current insomnia treatments by Edinger et al. (2021b) investigated the effectiveness of several psychological and behavioral treatments for insomnia. Their findings suggest that CBT-I is supported by the biggest body of research presenting moderate quality, followed by brief therapy for insomnia, which is a shortened form of insomnia therapy. Additionally, the meta-analysis discovered that there is some evidence to support the effectiveness of single CBT-I components, such as stimulus control or relaxation training, but the quality of the evidence was rated still low due to small sample sizes and risk of bias (Edinger et al., 2021b).

Another intervention assessed for the treatment of insomnia by Edinger et al. (2021b) was mindfulness. As there were only three quite small studies included in the analysis, the quality of evidence for mindfulness as insomnia treatment was rated as low. Due to this, there was no recommendation given for mindfulness in the subsequent practice guidelines (Edinger et al., 2021a). Yet, other reviews and meta-analyses, that focused on the effect of mindfulness on sleep specifically, draw a more positive picture of the effectiveness of mindfulness, therefore making it a topic of interest in current research (Kim et al., 2020; Rusch et al., 2019). Over the past years, the body of research done on mindfulness as a stand-alone or adjunct intervention for insomnia is growing, and a few empirically supported mindfulness-based treatments have already been used in the treatment of insomnia, such as mindfulness-based stress reduction (MBSR) (Garland et al., 2016).

What is mindfulness? The modern concept of mindfulness derived from Buddhist philosophy (Winbush et al., 2007), and describes the state of being aware of thoughts, emotions, and their interaction in the present moment in a non-judgmental way (Kim et al., 2020; Rusch et al., 2019). Some meditation practices usually aim to increase this non-judgmental awareness by focusing on specific aspects of our perception like breathing meditations, whereas other approaches, such as transcendental meditation, use techniques such as repeating a mantra over and over. Compared to CBT-I, which usually addresses the behavior and the content of cognitions about sleep (Edinger et al., 2021b), mindfulness does not address the content of thoughts but the individuals' relationship with them (Rusch et al., 2019). It is supposed that mindfulness can improve sleep by reducing arousal (Rusch et al., 2019) and increasing nonreactivity (Gao et al, 2021). The current emphasis on mindfulness as a skill acquired through training and practices like meditation and yoga could make it a valuable resource in addressing mental health problems. Particularly with the ongoing emergence of digital platforms, the possibility of delivering mindfulness training remotely could provide greater accessibility to rural or immobile populations. This review will therefore include both in-person and online administered applications of mindfulness-based interventions.

Recognizing the consequences of sleep disturbance and the need for a broader range of effective treatment options, this thesis intends to explore the current evidence for the effectiveness of mindfulness-based treatment in the management of insomnia and its' symptoms. Despite the many valuable insights yielded by previous reviews and meta-analyses (Garland et al., 2016; Kim et al., 2020; Riemann et al., 2021; Rusch et al., 2019, Winbush et al., 2007), there is still a need to synthesize new evidence and address the mechanisms by which mindfulness influences sleep (Garland et al., 2016). In the following sections, this thesis will

synthesize the current evidence for the effectiveness of mindfulness and explore through which mechanisms its effect on sleep is explained. By doing so, this review tries to make informed recommendations for future research, ensuring that patients suffering from sleep disturbances have the best choice of possible treatment options in the future. By addressing the research questions *"What is the current scientific evidence for the effectiveness of mindfulness-based interventions for the treatment of sleep problems in physically healthy adults?"* and *"What are the working mechanisms by which mindfulness-based interventions can improve sleep?"*, this review tries to map out the current state of knowledge and possible research gaps.

Methods

Inclusion and Exclusion Criteria

This study included peer-reviewed studies about adult populations suffering from insomnia and insomnia symptoms, which test the effectiveness of a mindfulness-based intervention. Included studies must report at least one valid measurement of sleep quality, either subjective (questionnaires, sleep diaries) or objective (actigraphy, polysomnography) and include both a description and judgement about the effectiveness of the used intervention. Only reports translated to or originally appearing in English and published in the last 10 years were included. Papers were excluded if they included children, adolescents, or populations suffering from physical illnesses (e.g., cancer). Additionally, studies assessing military, nursing or other occupational populations were excluded because the populations differ from clinical populations and because the circumstances of work-related interventions can vary a lot, making it difficult to draw generalizable conclusions. Studies that focus on solely female populations and related female phenomena like pregnancy or menopause were not included, because they are not representative of the broader population of people suffering from sleep disturbances.

Search Strategy

The search was performed on the online databases Scopus, PubMed and PsycINFO. For the preliminary search, article title, abstract and keywords were searched. As the body of research on the topics included is quite big, only title, abstract and keywords were searched for the preliminary search. To create a search string, the three main subject domains (mindfulness, sleep and effectiveness) were combined with the AND operator. Some topics that inflated the number of irrelevant search results were excluded from the search via the NOT operator, namely 'cancer', 'pain', and 'child'. The used search strings are reported in the Appendix. Scopus is a multidisciplinary database with high scientific importance. It covers a broad range of disciplines, particularly for health and social sciences (Burnham, 2006). PsycINFO, which

is a psychological database, was chosen because of its high emphasis on psychological research and mental health topics. Lastly, PubMed is a database with an emphasis on medical topics and is one of the most frequently used databases in the beforementioned fields. It was chosen because it is an important database for clinicians and researchers in the field (Falagas et al., 2007).

Study Selection

The data collection was done by one researcher alone. After completing the search and extracting the found articles, the duplicates were removed in EndNote (EndNote, 2023), a reference management tool that helps to organize literature for further use. All remaining articles were summarized into a RIS-file and opened in ASReview, a digital tool that helps with screening and selecting articles. ASReview utilizes active machine learning to help researchers with the screening process. After uploading the RIS-file, the artificial intelligence (AI) asks the user to determine a few relevant and a few irrelevant articles, thereby feeding information to the system which allows the AI to propose the most relevant sounding titles to the user first, who can then determine whether they will be excluded or included in the further screening process (ASReview, 2023).

After finding 93 articles with relevant-seeming titles, the AI stopped proposing any new relevant articles. All following publications suggested by the AI were not related to the research topic, and the title screening was finished. The set of available articles was again downloaded as RIS, and uploaded to Covidence, a website tool that helps to organize reviews (Covidence, 2023). In the following step, the abstracts of the articles were screened. After excluding 70 more articles due to irrelevant abstracts, the final list of 23 articles that were relevant was downloaded and each paper was read fully in order to determine their eligibility for the review. A paper was eligible if a) all inclusion criteria were met b) no exclusion criteria was met. The flowchart (figure 1) which is based on the PRISMA guidelines for reporting systematic reviews (Page et al., 2021), demonstrates the process of study selection.

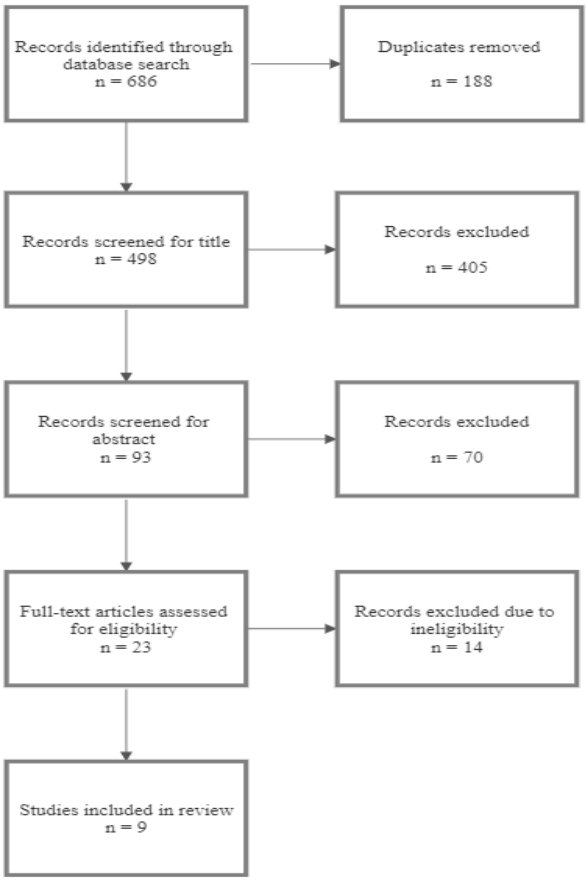

Figure 1

PRISMA flowchart of study selection process

Data Extraction

To synthesize the evidence and answer the first RQ, all relevant publications were read and reviewed. To get a comprehensive overview of the relevant articles' characteristics, a data extraction form was created. To map out the evidence for the effectiveness of the used interventions, the outcomes, conclusions about effectiveness, participant characteristics, and study characteristics were extracted. The characteristics included study design, the used intervention and control condition, way of delivery of the interventions, intervention duration, homework, the definition of sleep disturbance, and country of origin.

The Jadad scale (Jadad et al., 1996) was used to assess the quality of included studies. It is a tool that helps assess the quality of RCTs, by taking into account blinding, randomization, and drop-out rate, generating a score from 0 – 5. In the categories blinding, 2 or 0 points can be given; 2 if the study is double-blinded and 0 if it is not. For randomization, a score from 0-2 could be obtained, depending on whether the method of randomization is described properly (1 point) and whether the method is adequate (1 point). The last point is given when the dropout

numbers and reasons for dropouts are reported completely. In general, scores under 3 indicate low methodological quality and an increased risk of bias (Jadad et al., 1996).

To answer the second research question, the mechanisms used to explain the effect of mindfulness on sleep were extracted per article. The data extraction process was done by one researcher alone. Study design characteristics were extracted and reported to provide context of the methodology used to assess the effectiveness of mindfulness-based interventions. This gives an overview of different types of control conditions used, different types, lengths and ways of admission of mindfulness interventions, and the criteria used to determine sleep disturbances. Additionally, participant characteristics were extracted. To give an overview of the scope of the study, sample size and demographics (sex, age) were retrieved. Lastly, the outcomes of the studies were reported to provide an indication of the effectiveness of the specific intervention used. Reported measures include within-group effect sizes, between-group and group x time interaction effect sizes and reports of their significance. Additionally, the general findings of the studies were summarized to create an easily assessable overview of the studies' findings.

Results

Study and participant characteristics

In total, this systematic literature review included nine studies. Australia (n = 3) was the most prevalent origin country, followed by China (n = 2) and USA (n = 2). The other studies originated from Italy (n = 1) and Singapore (n = 1). Most studies were designed as randomized controlled trials (RCTs, n = 8), whereas one study employed a single-site trial (SST, n = 1) that did not use a control group. The landscape of mindfulness-based interventions in this review is quite broad, consisting of mindfulness-based treatment for insomnia (MBTI, n = 3), MBSR (n = 1), mindful awareness practices (MAPs, n = 1), online integral meditation classes (IM, n =1), mindfulness-based cognitive therapy (MBCT, n = 1), app-based mindfulness training (MT, n =1), and a smartphone application named Headspace (n =1). Four studies used specific active controls (SACs), namely sleep hygiene education exercise program (SHEEP, n =1), sleep hygiene education (SHE, n=1), psychoeducation with exercise control (PEEC, n =1), and progressive muscle relaxation (PMR, n =1), whereas only one study used a non-specific active control which was a usual care control (UCC, n=1). The other included studies did not use an active control condition but compared the intervention to a waitlist control (n = 3), one intervention did not control for the outcomes. The overall quality of the

reports ranged from 0 – 5, with most studies scoring 3 on the Jadad scale (n = 5), which can be considered adequate methodological quality.

Regarding admission, most studies were delivered in person (n = 5). Four studies in total were delivered online, most of them as apps or websites (n =3), the last one via online videoconferences (n =1). The interventions lasted either eight (n = 5) or six (n = 4) weeks. While all included studies focused on adult populations experiencing insomnia and insomnia symptoms, there are differences among the target groups. Three articles focused on a population of older adults, whereas the other papers included the whole adult population. Most studies focused on populations that experienced sleep disturbance without a necessity for clinical insomnia (n = 5), in contrast to the studies that only included participants with diagnosed insomnia (n = 3). One of the studies excluded participants with severe insomnia (ISI < 21). Only one study focused on a comorbid population, in this case a combination of anxiety and sleep disturbance (n =1). Sample sizes ranged from 23 – 216 (M = 74,2). Notably, most samples were comprised of mainly females (> 66 %, n = 6). The detailed demographic and study characteristics are reported in Table 1.

Outcomes

Table 2 displays the reported outcomes for sleep measurements within and between the group allocations, the general findings of included studies, and the mechanism/s by which studies explained the effects of mindfulness on sleep. Most studies included only subjective measurements of sleep, in the form of questionnaires (n = 4) or a combination of questionnaires and sleep diary entries (n = 1). The other studies combined subjective and objective sleep measures, either by combining questionnaires and sleep diary entries with actigraphy (n = 2), combining questionnaires with actigraphy and polysomnography (n =1), or combining questionnaires with actigraphy alone (n = 1). The most used subjective sleep outcomes were insomnia severity measured by the insomnia severity index (ISI, n = 6) and sleep quality measured by the Pittsburgh Sleep Quality Index (PSQI, n = 5). Other questionnaires used were the Pre-Sleep Arousal Scale (PSAS, n = 3), Sleep Condition Indicator (SCI, n = 1), Arousal Predisposition Scale (APS, n = 1), Ford Insomnia Response to Stress Test (FIRST, n = 1), Sleep Hygiene Index (SHI, n = 1), Epworth Sleepiness Scale (ESS, n = 1), Fatigue Severity Scale (FSS, n =1), Anxiety and Preoccupation about Sleep Questionnaire (APSQ, n=1). One study measured worry related sleep disturbance (WSRD) using five sleep disturbance items from Reported Outcomes Measurement Information System (PROMIS). Objective sleep measurements mostly included measurements of sleep efficiency (SE, n = 3), wake after sleep onset (WAO, n = 4), sleep onset latency (SOL, n = 4), and total sleep time (TST, n = 4).

Effectiveness

Specific active control

Four of the studies used specific active controls, two of them used a combination of subjective and objective sleep measures, one study only used PSQI, and one study used ISI combined with a sleep diary. Perini et al. (2021) (MBTI) and Wong et al. (2017) (MBCT) report significantly more reduction of insomnia severity in the mindfulness group compared to the active control. Both studies employed an 8-week intervention delivered in person. Low et al. (2020) (Headspace) reported significant reduction of insomnia severity in both the mindfulness group and the PMR control group, but the difference between the groups was not significant. Perini et al. (2020) observed a significant increase in sleep quality in both groups but did not find a significant difference between them. Contrary to that, Black et al. (2015) (MAPs) discovered a significant between-group effect on sleep quality, favoring mindfulness over sleep hygiene education.

Table 1

Study and Participants characteristics of included studies

Author	Country	Target Population	Sample size (female)	Mean Age (SD)	Study Design	Mindfulness Intervention	Control Intervention	Way of Delivery	Intervention Duration	Intervention hours	Sleep disturbance	Quality (Jadad Score)
Zhang et al. 2015	China	Elderly people with chronic insomnia	60 (25)	MBSR 78.47 (2.94) Control 77.63 (3.01)	RCT	MBSR	Waitlist	In-person	8 weeks	2 hours/ week + 2h retreat	Insomnia according to DSM4	Moderate (3)
Perini et al. 2021	Singapore	Older adults with insomnia symptoms	127 (74)	60.9 (6.4)	RCT	MBTI	SHEEP	In-person group sessions	8 weeks	2 hours/ week	PSQI > 5, + either (1) SOL > 30m (2) WASO > 30m or (3) TST < 6.5h	Moderate (3)
Black 2015	USA	Older adults with insomnia symptoms	49 (33)	66.3 (7.4)	RCT	MAPs	SHE	In person group sessions	6 weeks	2 hours/ week	PSQI > 5	Low (2)
Fazia et al. 2023	Italy	Adults with insomnia symtoms	56 (46)	MBI 53.96 (13.31) Control 53.46 (10.04)	RCT	IM	Waitlist	Online group sessions	6 weeks	2 hours/week	PSQI > 5	Moderate (3)
Kennett et al. 2021	Australia & New Zealand	Adults with insomnia symptoms	27 (26)	29.44 (11.97)	RCT	MBTI	Waitlist	Website modules (unguided)	6 weeks	N/A	ISI > 8	Moderate (3)
Wong et al. 2017	China	Adults with chronic insomnia	216 (169)	MBCT 55.6 (9.1) Control 55.6 (9.7)	RCT	MBCT	PEEC	In person group sessions	8 weeks	2.5h/ week	Chronic insomnia according to DSM5, ICD10	Moderate (3)
Gao et al. 2022	USA	Adults with anxiety and insomnia symptoms	80		RCT	MT	UCC	App modules (unguided)	8 weeks	N/A	PSWQ > 40, sleeping problems in more than 40% of nights	High (5)
Low et al. 2020	Australia	Adults with subclinical to moderate insomnia	23 (20)	36.39 (11.74)	Pilot Study	Headspace	PMR	App modules (unguided)	8 weeks	none	21 > ISI > 8	Low (1)
Peters et al. 2020	Australia	Adults with insomnia	30 (22)	48.7	UT	MBTI	none	In person group session	6 weeks	weekly	Insomnia according to DSM4	Low (0)

Coming to the objective sleep measures, Perini et al. (2021) and Low et al. (2020) found significant changes of WASO and SOL measured by actigraphy in the mindfulness group. Contrastingly, Perini et al. (2020) found a significant time x group interaction effect for WASO only, whereas Low et al. (2020) reported a significant time x group interaction effect for SOL only. Both findings favor mindfulness over the active control. Nevertheless, the outcomes from the PSG do not support the actigraphy-obtained findings by Perini et al. (2020), despite showing a significant within-group effect on WASO in the mindfulness group. Wong et al. (2017) report a significant time x group interaction effect on WASO according to the participants' sleep diaries, but no significant interaction effect was observed for SOL, TST, or SE. Low et al. (2020) reported significant within-interaction effects in both groups on sleep-diary outcomes of total wake time (TWT) and cognitive PSAS , but no significant difference between the groups. Additionally, they found a significant within-group effect on somatic PSAS in the mindfulness group and not in the active control, but the difference of effect size was not significant (p = .12).

Usual care control

One study by Gao et al (2022) used a usual care control group. Main sleep outcomes were WRSD measured with a questionnaire and actigraphy-measures from a Fitbit of TST and SE. A significant group x time interaction effect was observed for WRSD, showing a greater reduction in the mindfulness group compared to the usual care control. Actigraphy outcomes indicated no significant differences between the groups on both measures after imputing missing data, but in the analysis using only obtained data they found a small but significant between-group effect on TST, with a greater increase of TST in the mindfulness group.

Waitlist control

Three studies compared mindfulness to a waitlist control. Notably, none of them used objective measurements or a sleep diary, all relied on questionnaires at pre-and post-treatment. Two of the papers used the PSQI (Fazia et al., 2023; Zhang et al., 2015) and two of the papers used the ISI (Fazia et al., 2023; Kennet et al., 2021). Other outcomes included PSAS (Kennett et al., 2021), as well as APS, SCI, FIRST, and SHI (Fazia et al, 2023). Fazia et al. (2023) and Zhang et al. (2015) reported a significant group x time interaction effect on sleep quality, with a significantly higher increase of sleep quality in the mindfulness group. Adding to that, Fazia et al. (2023) found a significant between-group effect and group x time interaction effect on insomnia severity, preferring mindfulness over the waitlist control. These findings are supported by Kennett et al. (2021), who also reported significant between-group and group x time interaction effects on insomnia severity in favor of the mindfulness group. No significant

effects of the treatment could be observed for scores on SCI, APS, FIRST, or SHI (Fazia et al., 2023). Kennett et al (2021), who evaluated the effect on pre-sleep arousal, found significant group x time interactions for both cognitive and somatic arousal, indicating a greater reduction of arousal in the mindfulness group.

Uncontrolled

One study included in this review did not use a control condition but used a lot of different subjective and objective outcome measures to assess the effectiveness of mindfulness (Peters et al., 2020). For the subjective measurements, significant effects of mindfulness could be observed on insomnia severity, sleep quality, anxiety and preoccupation about sleep, SE and WASO (Peters et al., 2020). No significant effects were found for sleepiness, fatigue severity, pre-sleep arousal, and TST (Peters et al., 2020). Actigraphy indicated significant effects on TST and SOL, and no significant effects on SE and WASO (Peters et al., 2020).

Mechanisms

Seven of the included articles mentioned mechanisms by which their mindfulness intervention is thought to influence the process of sleep. The most mentioned pathway of action mentioned by the articles is the reduction of physical and psychological arousal, as mentioned by Perini et al. (2021), Black et al. (2015), Kennet et al. (2021), Low et al. (2020), and Peters et al. (2020). Having said that, only four of these papers used measures to assess pre-sleep arousal (Kennet et al., 2021; Low et al., 2020; Peters et al., 2020; Perini et al., 2021). The study by Perini et al. (2021) found a significant within-group effect for cognitive but not somatic PSA in both groups, but no significant differences between the groups. The same was observed by Low et al. (2020), reporting a significant within-group effect of mindfulness on cognitive arousal but not on somatic arousal, despite a high effect size on cognitive arousal. This was not observed in the control group. Nevertheless, no significant between-group or time x group interaction effect was recognized. Contrastingly, Kennet et al. (2021) demonstrated a significant time x group interaction effect on both cognitive and somatic PSAS. Within-group effect sizes were not reported by Kennet et al. (2021) nor by Peters et al (2020).

Another possible mechanism by which mindfulness influences sleep is an increase of nonreactivity, meaning reduced reactivity to stressful external or internal stimuli (Black et al., 2015; Gao et al., 2020). Whereas Black et al. (2015) only discuss it as the potential mechanism for their intervention without measuring it, Gao et al. (2020) assessed nonreactivity with the corresponding subscale of the Five-Facet Mindfulness Questionnaire (FFMQ). They observed a significant within-group effect of mindfulness on increase in nonreactivity but could not observe that in the control group (Gao et al., 2020). Furthermore, Gao et al. (2020) reported

both a significant between-group effect and a significant group x time interaction effect in favor of the mindfulness-based intervention. Subsequent mediation analyses showed a significant mediation effect of non-reactivity on changes in worry-related sleep disturbance by reducing worry. (Gao et al., 2020).

Perini et al. (2023) also included reduction in dysfunctional beliefs about sleep (DBAS) as possible mechanism. In their analysis, both the active control group (SHEEP) and the mindfulness group showed significantly decreased scores on DBAS scale. No significant time x group interaction was observed (Perini et al., 2023).

Table 2

Outcomes of Effectiveness from baseline to posttreatment of included studies

Authors	Sleep Measurements	Mindfulness Within group effect size	Control Within group effect size	Between group effect size/ p value	Group x Time Effect size / p value	General findings	Working mechanism
Zhang et al. 2015	PSQI	1.12 *d*	-0.06 *d*	NR	NR / *p* = .006	MBSR significantly better outcomes than waitlist control on sleep quality	NR
Perini et al. 2021	ISI	-1.27 *d**	-0.69 *d**	NR	NR / *p* = .01*	Both treatments are effective, MBTI significantly more effective on Insomnia severity, but not sleep quality. Objective measurement shows significantly more reduced WASO in MBTI group	Reduction of arousal and changes in dysfunctional beliefs about sleep
	PSQI	-1.19 *d**	-1.02 *d**	NR	NR / (not sig)		
	PSAS Som	-0.19 *d*	-0.16 *d*	NR	NR / (not sig)		
	PSAS Cog	-0.56 *d**	-0.37 *d**	NR	NR / (not sig)		
	DBAS	-0.68 *d**	-0.51 *d**	NR	NR / (not sig)		
	Actigraphy						
	WASO	-0.3 *d**	-0.025 *d*	NR	NR / *p*=.019*		
	SOL	-0.25 *d**	0.088 *d*	NR	NR (not sig)		
	PSG						
	WASO	-0.26 *d**	-0.18 *d*	NR	NR (not sig)		
	SOL	-0.004 *d*	-0.054 *d*	NR	NR (not sig)		
Black et al 2015	PSQI	NR	NR	0.89 *d* / *p*=.002*	NR	MAPs showed significantly greater effect on sleep quality than the control group	Reduction of arousal and reactivity
Fazia et al. 2023	PSQI	NR	NR	-0.67 *g**	-0.25ß / *p* =.04 *	Online administered IM shows beneficial effect on sleep quality and decreased insomnia severity compared to waitlist control	NR
	APS	NR	NR	0.17 *g*	0.06ß / *p* = .68		
	SCI	NR	NR	0.66 *g*	0.27ß / *p* = .07		
	FIRST	NR	NR	-0.12 *g*	0.66ß / *p* = .73		
	ISI	NR	NR	-0.78 *g**	-0.38ß / *p* = .04*		
	SHI	NR	NR	-0.012 *g*	-0.04ß / *p* = .73		
Kennet et al. 2021	ISI	NR	NR	1.49 *d**	0.41 η^2 / *p* < .001*	dMBTI shows significant improvements in pre-sleep arousal and insomnia severity compared to waitlist control	Reduction of arousal
	PSAS Som	NR	NR	-0.24 *d*	0.19 η^2 / *p* = .02*		
	PSAS Cog	NR	NR	-0.35 *d*	0.48 η^2 / *p* = .03*		
Wong et al. 2017	ISI	-1.062 *d*	-0.613 *d*	-0.36 *d*	NR / *p* =.023*	MBCT showed small but significant benefits at post-treatment on insomnia severity compared with PEEC control	NR
	Sleep Diary						
	SOL	-0.499 *d*	-0.438 *d*	0.024 *d*	NR / *p* = .315		
	WASO	-0.469 *d*	-0.108 *d*	-0.499 *d*	NR / *p* = .049*		

	TST	0.465 *d*	0.290 *d*	0.142 *d*	NR / *p* = .949		
	SE	0.510 *d*	0.357 *d*	0.129 *d*	NR / *p* = .63		
Gao et al. 2022	WRSD	NR	NR	NR	-3.0ß / *p* = .002*	MT reduces WRSD and nonreactivity significantly compared to waitlist control	Increase of nonreactivity
	FFMQ - nonreactivity	0.71 *d**	NR / NS	NR / *p* < .001*	3.8 ß / *p* < .001*		
	Actigraphy						
	TST	NR	NR	NR / *p* = .04*	NR		
	SE	NR	NR	NR / NS	NR		
Low et al. 2020	ISI	1.61 *d**	1.97 *d**	NR	0.003 η^2 / *p*=.79	Boths groups showed beneficial effects on sleep. Besides a lower SOL in the Headspace group, no other significant differences were observed	Reduction of arousal
	Actigraphy				`		
	TIB	0.34 *d*	0.00 *d*	NR	0.33 η^2 / *p* = .28		
	TST	0.15 *d*	0.25 *d*	NR	0.46 η^2 / *p* = .86		
	SOL	1.67 *d**	0.02 *d**	NR	0.02 η^2 / *p* = .02*		
	WASO	0.27 *d**	0.26 *d**	NR	0.01 η^2 / *p* = .86		
	SE	0.73 *d*	0.05 *d*	NR	0.37 η^2 / *p* = .51		
	SFI	0.05 *d*	0.25 *d*	NR	0.58 η^2 / *p* = .46		
	Sleep Diary						
	TWT	0.48 *d**	0.83 *d**	NR	0.005 η^2 / *p* = .77		
	PSAS Som	1.08 *d*	0.05 *d*	NR	0.12 η^2 / *p* = .12		
	PSAS Cog	0.98 *d**	0.74 *d*	NR	0.007 η^2 / *p* = .71		
Peters et al. 2020	ISI	1.17 *d**	-	-	-	MBTI shows significant improvement of insomnia severity, sleep disturbance, SOL, WASO, sleep efficiency. Both subjective and objective data support that.	Reduction of arousal
	PSQI	1.02 *d**					
	ESS	NR / NS					
	FSS	NR / NS					
	APSQ	1.2 *d**					
	PSAS Som	NR / NS					
	PSAS Cog	NR / NS					
	Actigraphy						
	TST	0.61 *d**					
	SE	NR / NS					
	SOL	0.93 *d**					
	WASO	NR / NS					
	Sleep Diary						
	TST	NR / NS					
	SE	0.52 *d**					
	WASO	0.81 *d**					

* = significant; NR = not reported

Discussion

This review intended to look at the current scientific evidence for the effectiveness and the possible mechanism by which mindfulness interventions influence sleep. The evidence summarized in this paper suggests that mindfulness can influence various subjective sleep parameters in adult populations suffering from sleep disturbances, making it a possibly effective treatment for insomnia. When comparing mindfulness to specific active control conditions, the findings are mixed, with better outcomes for the mindfulness treatment on some parameters, but not at all. In general, the active control groups were also effective in reducing insomnia. Comparing the mindfulness intervention to waitlist or usual care control conditions, the evidence suggests that mindfulness is an effective treatment approach to tackle insomnia. Altogether, this means that despite being an effective treatment approach for insomnia, it might not be the best stand-alone treatment for insomnia but rather a useful adjunct to the current treatment landscape.

While some studies indicate a superiority of mindfulness to SHEEP and PEEC (both treatments incorporate education about sleep and exercise) in reducing insomnia severity (Perini et al., 2021; Wong et al, 2017), another study found no superiority or inferiority compared to PMR (Low et al., 2020). Followingly, superior effectiveness of mindfulness compared to SHE on subjective sleep quality was observed by Black et al. (2015), while Perini et al (2021) could not find a difference in effectiveness on sleep quality compared to SHEEP. According to Perini et al. (2021), a possible explanation for that is that SHEEP uses more active components than usual sleep hygiene approaches by incorporating physical exercise (Perini et al., 2021). Notably, Perini reported a significant with-in group effect for both groups, indicating that both treatments were effective.

While subjective sleep outcomes are important indicators for the effectiveness of interventions, objective sleep measures can give us hints about the effect of interventions on actual sleep parameters. Studies comparing mindfulness to active controls did not draw a coherent picture of the effects of mindfulness on SOL and WASO. While Perini et al. (2021) found a significant between-group effect of mindfulness on WASO but not on SOL measured by actigraphy, Low et al (2020) reported opposite outcomes, indicating superiority of mindfulness decreasing SOL but not WASO. Polysomnography measures utilized by Perini et al. (2021) did not confirm the observations obtained from actigraphy. It is nevertheless important to be cautious about the importance of objective sleep parameters for insomnia, as the differences between insomniacs and healthy individuals are smaller on objective measurements than on subjective measurements (Lundh & Broman, 2000). The current

evidence does not suggest a superiority of mindfulness in influencing SOL or WASO compared to active control, but the strength of evidence is low. Furthermore, objective sleep measures alone cannot account for the symptoms that people with sleep disturbances and insomnia experience. After all, insomnia is not equal to sleep deprivation, and previous research has shown that their symptoms differ from each other a lot (Lundh & Broman, 2000).

Despite mixed evidence for the effectiveness of mindfulness when compared to specific active control conditions, the evidence generated by studies using waitlist controls or no control suggests that mindfulness is effective at increasing subjective sleep quality (Fazia et al., 2023; Peters et al., 2020; Zhang et al., 2015) and decreasing insomnia severity (Fazia et al., 2023; Kennet et al., 2021; Peters et al., 2020). These findings demonstrate that it might be more important that someone does seek treatment than it is important which treatment they seek. No study utilizing a waitlist control found contrasting evidence, which further consolidates the findings. Despite these promising results, findings should be taken with caution, as the studies used different interventions on different populations and used small sample sizes. The uncontrolled study by Peters at al. (2020) utilized also actigraphy, indicating effectiveness on total sleep time and sleep onset latency. Unfortunately, these findings are not generalizable to the broader population, as the very small sample comprised a sleep clinic population. As a consequence of that, further investigation using active controls in an outpatient setting is required.

As this review suggests, the current understanding of the mechanisms by which mindfulness influences sleep is still limited, even though there seems to be general agreement on some of the mechanisms in current research. One mechanism that the current narrative seems to agree upon is that mindfulness reduces hyperarousal, which is one of the factors contributing to sleep disturbances (Ong et al., 2012). The studies assessing pre-sleep arousal that were included in this study found evidence that mindfulness decreases pre-sleep arousal, but the evidence was not coherent when comparing these effects to active controls. A possible explanation for this is that the reduction of hyperarousal might be an underlying mechanism of different treatment approaches, which is not only addressed by mindfulness-interventions but also by the other active interventions included in this review. As mentioned in the insomnia model by Lundh and Broman (2000), hyperarousal is one of the main factors in determining one's vulnerability to insomnia symptoms. Notably, the studies incorporating active controls by Low et al (2020) and Perini et al. (2021) both used control interventions that aim at reducing physiological arousal. In fact, both the mindfulness- and the control interventions were able to decrease arousal, as can be seen in the change in PSAS scores. Following that, it is reasonable

to assume that current evidence supports rather than challenges the view that mindfulness influences sleep by reducing arousal.

A mechanism that might be more unique to mindfulness is nonreactivity, which can be described as the ability to detach from one's experience, thereby decentering from possibly negative cognitions and emotions (Gao et al., 2022). In their study, Gao et al. (2022), who make for a unique case in the study as it is the only one incorporating a comorbid population, found a significant effect of mindfulness on nonreactivity and worry-related sleep disturbance. Their argument that by increasing nonreactivity one can reduce worry and therefore worry-related sleep disturbance was further supported by their subsequent mediation analysis. Nevertheless, as they used a usual care control which is active but not specified, no conclusions can be drawn about whether this mechanism might be unique to mindfulness or not. Having said that, it remains open whether this mediation effect is also applicable to sleep quality or insomnia severity.

The last mechanism that was used to describe the effects of mindfulness interventions on sleep is the reduction of dysfunctional beliefs about sleep (Perini et al., 2021). Dysfunctional beliefs about sleep, which are described by Lundh and Broman (2000) as sleep-interpreting processes, include beliefs about the amount of sleep necessary and the consequences of poor sleep, and ongoing evaluation and judgment of one's sleep. The findings reported by Perini et al. (2021) give preliminary evidence that mindfulness can reduce dysfunctional beliefs about sleep, but the same effect was observed in the active control. Additionally, it was not assessed whether the reduction in dysfunctional beliefs about sleep actually mediated the effect of mindfulness on sleep. Further exploration of this mechanism is therefore necessary.

Recommendations for Future Research

Due to the preliminary evidence for the effectiveness of mindfulness-based treatments for insomnia and insomnia symptoms described in this paper, this review supports further exploration of the issue. In the following, some recommendations for future directions are given.

The first recommendation takes into account the current culture of reporting measurement outcomes. Many reports included in this study did not report their outcomes fully but focused on reporting significant outcomes only, therefore increasing the risk of bias (Chan & Altman, 2005). This makes it harder for subsequent meta-analyses and literature reviews to evaluate findings across multiple studies. By reporting also non-significant outcomes and effect sizes, studies could draw a more transparent picture of their work and increase their credibility.

Secondly, this review recommends that future studies use a mix of both subjective and objective measurements for sleep. As mentioned by Lundh and Broman (2000), people suffering from insomnia symptoms usually over- or underestimate sleep parameters like SOL or WASO. When incorporating sleep diary measures, it would be beneficial to compare them to objective measurements of assessed sleep parameters to determine participants' possible misperceptions of their sleep.

The third recommendation targets the current assessment of the mechanisms by which mindfulness may influence sleep. Despite the general consensus that mindfulness primarily tackles sleep disturbance by decreasing hyperarousal, findings of current research are not fully coherent. Adding to that is the fact that none of the studies included in this review that measures PSAS performed subsequent mediator analyses. It would be very insightful to check for possible correlations between PSAS, DBAS, or nonreactivity scores and different sleep outcomes such as sleep quality or insomnia severity. Especially comparing the working mechanisms of CBT-I, which is the current standard treatment, and mindfulness-based approaches would draw a clearer picture of their differences and similarities, making it easier to decide which treatment benefits whom the most, and whether combining them would even increase the effectiveness.

Limitations

The first limitation of this study is that it was performed by one researcher alone. As the selection of relevant articles for the study is based on subjective judgment, incorporating a second researcher could increase the likelihood of all relevant articles being included (Stoll et al., 2019). When working alone, it is not unlikely to dismiss possibly beneficial search terms and inclusion criteria. Because of that, there is a possibility that not all relevant articles from the databases have been found. Furthermore, quality assessment of articles is usually done by at least two researchers to account for inter-rater reliability (Jadad et al., 1996). Therefore, quality judgements in this paper should be taken with caution despite their systematic approach,

Secondly, this review assessed a lot of different mindfulness-interventions across a broad range of ways of admission. While this gives a good overview of the effectiveness of mindfulness-based treatments in general, it does not consolidate evidence for the effectiveness of specific, empirically developed interventions like MBTI, as it included less specific mindfulness interventions like integral mindfulness or mindful awareness practices which are not primarily targeted at sleep but mindfulness in general. Nevertheless, the decision was made to include all mindfulness interventions because it better represents the landscape of current research on mindfulness. As mentioned by Perini et al. (2021), the heterogeneity of

mindfulness-based interventions is big, so a literature review assessing the current state of the evidence should also represent this heterogeneity.

Conclusion

The evidence presented in this review supports the effectiveness of mindfulness-based interventions for the treatment of sleep disturbances. Nevertheless, further exploration of different treatments and their specific characteristics is necessary to develop treatments with the highest possible effectiveness. Despite a general agreement on the supposed mechanisms by which mindfulness influences sleep, there is little to no evidence in current sleep research that the supposed mechanisms really account for the effect of mindfulness. Mindfulness-based treatments for sleep disturbances show the potential to be either an adjunct to usual treatment or a stand-alone intervention. Whether we can capitalize on this potential depends on the direction that future research will take. Finally, this review recommends further research that includes mediation analysis of the working mechanisms and direct comparisons to CBT-I.

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Appendix

Search strings used in the literature search

Date	Source	Search String	Total Hits
24.4	PsycINFO	(mindfulness OR mindfulness-based OR mbsr OR mbti OR mindful*) AND (sleep OR sleep quality OR sleep intervention OR insomnia OR sleep problems) AND (effectiveness OR evidence OR evaluation OR efficacy)NOT (cancer OR "pain" OR child*)	171
24.4	Scopus	(TITLE-ABS-KEY (mindfulness OR mindfulness-based OR mbsr OR mbti OR mindful*) AND TITLE-ABS-KEY (sleep OR sleep AND quality OR sleep AND intervention) AND TITLE-ABS-KEY (effectiveness OR evidence OR evaluation OR efficacy) AND NOT TITLE-ABS-KEY (cancer OR pain OR child*)	258
24.4	Pubmed	(mindfulness OR mindfulness-based OR mbsr OR mbti OR mindful*) AND (sleep OR sleep quality OR sleep intervention OR insomnia OR sleep problems) AND (effectiveness OR evidence OR evaluation OR efficacy)NOT (cancer OR "pain" OR child*)	257
			686