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Mind-body therapies for sleep disturbance among patients with cancer: A systematic review and meta-analysis

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ABSTRACT

Objectives: To assess whether mind-body therapies (MBTs) are effective for relieving sleep disturbance among patients with cancer.
Design: Systematic review and meta-analysis of randomized controlled trials (RCTs).
Methods: Seven English electronic databases were searched from the date of inception to September 2022. All RCTs that included adults (≥18 years) who were treated with mindfulness, yoga, qigong, relaxation, and hypnosis were screened. The outcome was subjective and/or objective sleep disturbance.The revised Cochrane tool (RoB 2.0) was applied to evaluate the risk of bias. The RevMan software was applied to assessed each outcome according different control groups and assessment time points. Subgroup analyses were performed according to different categories of MBTs.
Results: Sixty-eight RCTs (6339 participants) were identified. After requesting for missing data from corresponding authors of included RCTs, 56 studies (5051 participants) were included in the meta-analysis. The meta-analysis showed a significant immediate effect of mindfulness, yoga, relaxation, and hypnosis on subjective sleep disturbance, compared with usual care or wait list control, and the effect of mindfulness lasted at least 6 months. For objective sleep outcomes, we observed significant immediate effects of yoga on wake after sleep onset and of mindfulness on sleep onset latency and total sleep time. Compared with active control interventions, MBTs had no significant effect on sleep disturbance.
Conclusions: Mindfulness, yoga, relaxation, and hypnosis were effective in sleep disturbance severity reduction among patients with cancer at post-intervention, and the effect of mindfulness lasted at least 6 months. Future MBTs studies should apply both objective and subjective sleep measurement tools

1. Introduction

Sleep disturbance is a common problem for patients with cancer. The incidence rate of sleep disturbance among patients with cancer ranges from 30% to 93%, which is three times that of non-cancer populations (9–33%).[1,2] Poor sleep persists in patients diagnosed with and undergoing treatment for cancer and can last for months or years after complete treatment.[3,4] In patients with cancer, sleep disturbance is associated with physical fatigue, psychological distress, cognitive impairment, and poor quality of life;[5–7] further, it increases the risk of infection and death.[8,9] The underlying mechanism of cancer-induced sleep disturbance is multi-factorial[10] and appears to be associated with inflammation, endocrine factors, neurological factors, metabolic stress, circadian disruption, and other factors.[11] Liu et al.[12] found that the poor sleep quality of patients with breast cancer is related to changes in the levels of inflammatory markers, such as interleukin-1, interleukin-6, and tumor necrosis factor; moreover, these inflammatory cytokines can directly affect sleep nuclei, neurotransmitters, and the

Abbreviations: CBT, cognitive-behavior therapy; EORTC-QLQ-C30, European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Core 30; ISI, Insomnia Severity Index; MBCT, mindfulness-based cognitive therapy; MBT, mind-body therapies; MBI, mindfulness-based intervention; MBSR, mindfulness-based stress reduction; PROMIS, Patient-Reported Outcomes Measurement Information System; PSQI, Pittsburgh Sleep Quality Index; RCTs, randomized controlled trials; SE, sleep efficiency; SOL, sleep onset latency; TST, total sleep time; UC, usual care; WASO, wake after sleep onset; WL, wait list.

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hypothalamic-pituitary-adrenal (HPA) axis, thereby disrupting circadian rhythms and leading to sleep disturbance.[11]

Benzodiazepines are considered the primary treatment option for sleep disturbance. However, sleep medications have side effects, such as drug dependence, impaired cognitive attention, and suicidal tendency.[13] Recent studies have suggested that a growing number of patients use complementary and alternative medicine, which have begun showing benefits. The National Comprehensive Cancer Network has suggested the use of cognitive-behavior therapy (CBT) to treat sleep disturbance in survivors of cancer.[14] CBT, a psychological therapy, is administered by professional therapists, which might limit its popularization.[15] In the last two decades, the world has developed a growing interest in mind-body therapies (MBTs), which have been broadly defined as a group of therapies that emphasize the use of the brain and mind in conjunction with the body and behavior to assist in the healing process.[16] MBTs can be easily learned and practiced by patients and are widely available to hospitalized patients as well as community-dwelling individuals. MBTs may influence neural regions that regulate downstream stress response pathways, including the autonomic nervous system and the HPA axis, through increased anti-inflammatory signaling, which may stabilize the circadian rhythm and protect sleep health.[17]

The efficacy of a wide range of MBTs for sleep in patients with cancer has been studied in randomized controlled trials (RCTs). Reviews have demonstrated that MBTs such as mindfulness,[18] yoga,[19] and qigong[20] may be significantly associated with subjective sleep disturbance alleviation. Few of the reviews assessed objective sleep outcomes and analyzed the effect of MBTs compared with different control interventions. No review has hitherto examined the efficacy of MBTs at different follow-up times. Herein, we focused on six types of MBTs that have received considerable research attention and are consistent in PubMed, MeSH, and Cochrane Reviews: mindfulness (such as mindfulness-based stress reduction [MBSR], mindfulness-based cognitive therapy [MBCT], meditation, and other mindfulness-based interventions [MBI]), hypnosis, relaxation, imagery, yoga, and qigong (including taichi). Both qigong and taichi are mind-body exercises rooted in traditional Chinese medicine, and taichi is derived from qigong.[21] The aim of the present systematic review was to assess the efficacy and effect duration of MBTs for subjective and objective sleep disturbance alleviation in patients with cancer.

2. Methods

This systematic review and meta-analysis was conducted following the Cochrane Handbook and reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement 2020 (PRISMA 2020). The protocol for this study was registered in the International Prospective Register of Systematic Reviews (registration number: CRD42022361192).

2.1. Search strategy

For this systematic review and meta-analysis, the following seven electronic databases were searched from the date of inception to September 2022: MEDLINE, Embase, CINAHL via EBSCO Host, Cochrane Library, Scopus, PubMed, and PsycINFO. Because there is no official list of MBTs, the MBTs evaluated in this systematic review were based on three information sources: PubMed, MeSH, and Cochrane Reviews related to Complementary Medicine. Search logic included (neoplas* OR cancer* OR carcinoma* OR tumour* OR adenocarcinoma* OR leukemi* OR leukaemia* OR lymphoma* OR malignan* OR melanoma* OR sarcoma*) AND ((mind body therap*) OR (mind body intervention*) OR (mindfulness based*) OR (mindfulness based stress reduction) OR mbsr* OR (mindfulness based cognitive therapy) OR mbct* OR meditation* OR mindfulness* OR taichi OR (tai chi*) OR (tai ji*) OR qigong OR (chi kung) OR (qi gong) OR (baiduanjin*) OR yoga OR hypnosis OR imagery OR relaxation) AND (insomnia OR dyssomnia OR (sleep disorder*) OR (sleep disturbance) OR insomni* OR sleep*). The full list of search terms and strategies is provided in Appendix A. All potentially eligible studies were considered for review, irrespective of the primary outcome. The reference lists of identified studies for inclusion or published reviews were also manually searched. English language and no limits on the date of publication were set for the search.

2.2. Inclusion and exclusion criteria

Inclusion criteria were presented in the format of participants (P), interventions (I), comparisons (C), outcomes (O), and study design (S).

P: adult patients with cancer, age $\geq$ 18 years.

I: MBT, including mindfulness, hypnosis, relaxation, imagery, yoga, and qigong (including taichi). However, the interventions did not include cognitive behavioral therapy, suggestion, autogenic training, music, and art, which were not consistent in PubMed, MeSH, and Cochrane Reviews.

C: treatment as usual/standard care (UC), wait list (WL), active control (support groups and other active interventions).

O: subjective sleep outcomes (insomnia, sleep disturbance, and sleep quality) and objective sleep outcome (sleep efficiency [SE], wake after sleep onset [WASO], sleep onset latency [SOL], and total sleep time [TST]).

S: RCTs.

Studies without full texts or protocols, conference abstracts, and books were excluded. Moreover, studies were excluded if they lacked sufficient important details about the intervention, or if there was a combination of MBTs and other interventions.

2.3. Study selection

All records identified from databases were entered and duplicated by EndNote X9 software (Clarivate Analytics, PA, USA). Two reviewers (JH and LB) independently screened the titles and abstracts of the remaining records according to the selection criteria. Thereafter, the full texts of potentially relevant studies were retrieved and assessed by both reviewers. Any disagreement was discussed among all of the authors to reach a consensus.

2.4. Risk of bias

Two reviewers (JH and LB) independently assessed the risk of bias in the included RCTs using the revised Cochrane tool (RoB 2.0) in five distinct domains: the randomization process, intended interventions, missing outcome data, outcome measurement, and selection of the reported outcome. The two reviewers independently answered one or more signaling questions within each domain, and the answers led to judgments of “low risk of bias”, “some concerns”, or “high risk of bias”. The judgments within each domain led to an overall risk-of-bias judgment for the result being assessed.[22] The corresponding author (AM) was consulted when any disagreements arose in order to reach a consensus.

2.5. Data extraction

The two reviewers independently extracted the following data from the included RCTs: source, study design, participants, intervention, comparator, outcome measures of sleep, and measured time points. The mean and standard deviation (SD) of sleep outcomes were extracted from the studies. For trials that reported their continuous variables as mean with ranges, we converted those variables into the mean and SD using the method proposed by Hozo et al.[23] Outcome data were extracted from published figures using GetData Graph Digitizer if the data were not available in tables. For original publications that did not provide sufficient data, reviewers requested the missing data from corresponding authors via email.

2.6. Data analysis

We conducted a narrative synthesis of the entire body of studies. Mixed-effects meta-analyses were conducted using RevMan 5.3 for sleep outcomes in all studies for which we could extract data. Meta-analyses were conducted based on different control groups and assessment time points. For subjective sleep disturbance, different studies used different evaluation tools, such as sleep-related questionnaires (e.g., Pittsburgh Sleep Quality Index [PSQI] and Insomnia Severity Index [ISI]) and sleep-related items of quality-of-life questionnaires (e.g., European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Core 30 [EORTC-QLQ-C30] and Patient-Reported Outcomes Measurement Information System [PROMIS]). Effect size estimates were calculated as standardized mean differences (SMD). For objective sleep outcomes, although the instruments were different (e.g., actigraphy, polysomnography, sleep diary, and armband), the sleep characteristics (SE, WASO, SOL, and TST) had the same units. Effect size estimates were calculated as weighted mean differences (WMD). Publication bias was examined using funnel plots. Heterogeneity was investigated using I^2 statistics between studies; studies with $I^2 > 50\%$ were considered to have moderate to high heterogeneity.[24] Given the expected variability of included studies, a random-effects model was used for meta-analysis. In cases where the number of studies was sufficient, subgroup analyses were conducted separately based on different MBT categories. Sensitivity analysis was conducted by excluding the studies with highly positive results. In this study, the immediate effects were analyzed using post-intervention data; the short-, mid-, and long-term effects were analyzed using follow-up data assessed < 3 months, ≥ 3 months and < 6 months, and ≥ 6 months after the intervention, respectively. The last follow-up data were used for follow-ups with more than one dataset.

3. Results

3.1. Study selection

A total of 3272 citations were identified from the databases. Four hundred full-text articles were selected for further review following duplicate removal and title and abstract review. Sixty-eight RCTs (with 6339 participants) were included in the review, after full-text articles assessed and linked multiple reports of the same study (including 3, 2, 1, and 1 reports on yoga,[25–27] relaxation,[28,29] mindfulness,[30] and qigong,[31] respectively). The flow diagram of study retrieval and selection was shown in Fig. 1.

3.2. Characteristics of included studies

The characteristics of the 68 included studies are summarized in Table 1. Of the included studies, 41 (39 in the USA and 2 in Canada), 20, 6, and 1 studies were conducted in North America, Asia, Europe, and Australia, respectively. Twenty-two studies were pilot RCTs with sample sizes ranging from 10 to 97, whereas 46 studies were full RCTs with sample sizes ranging from 47 to 336. Sixty-six studies were parallel RCTs and two studies were cross-over RCTs. Fifty-five, 10, and 3 studies included 2, 3, and 4 groups, respectively. Thirty-five studies focused on breast cancer with 100% female participants, and the remaining 33 studies included a single or mixed cancer type, such as hematologic malignancies, head and neck cancer, lung cancer, hepatocellular carcinoma, colorectal cancer, prostate cancer, and cervical cancer. The mean age of participants ranged from 33.6 to 68.3 years.

The included studies examined mindfulness (n = 24), yoga (n = 20), qigong (n = 11), relaxation (n = 9), hypnosis (n = 2), guided imagery (n = 1), and mixed mind-body intervention (n = 1). In addition, the studies used a range of control conditions, including UC (n = 24), WL (n = 23), and other active controls such as self-care education, attention control, aerobic exercises, and CBT (n = 21). The interventions were conducted at various time points, including the perioperative period as well as during chemotherapy or radiotherapy, active treatment

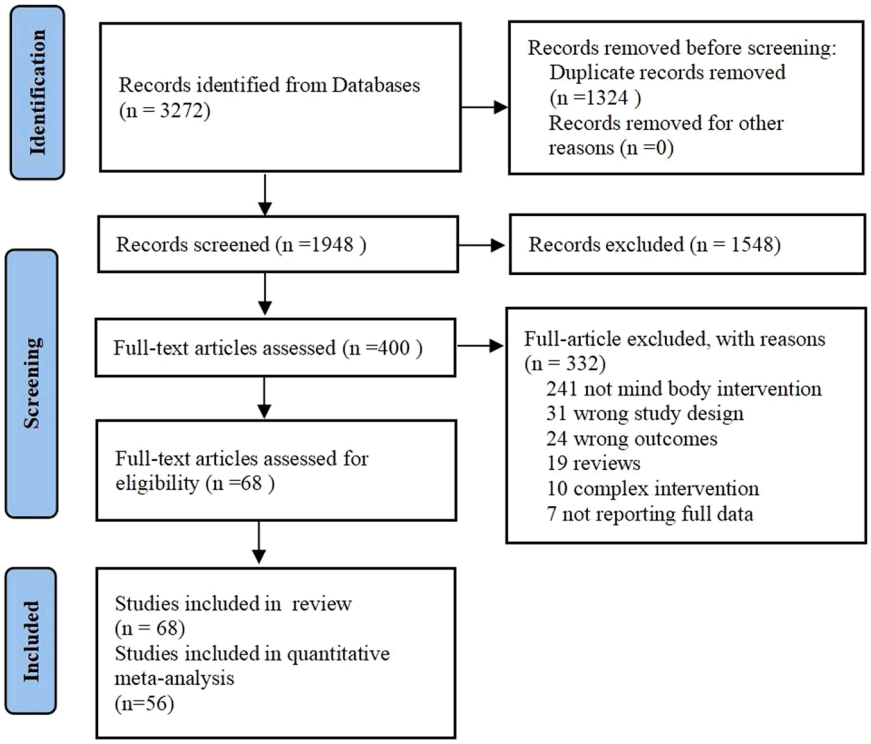

Fig. 1. Study flow diagram.

Table 1
Data extraction form of 68 studies.

Source	Study Design	Sample size (N); population	Intervention, N	Control, N	Time point/ details of intervention	Mean Age (SD) (year)	Women (%)	Measurement of sleep health	Measured time point
Bower et al. (2015) USA	Parallel RCT	71, breast cancer (stage 0- III)	Meditation, 39	WL, 32	Completed active treatment (except hormone therapy) at least 3 months previously; Intensity: 6 weekly 2-hour group sessions, 5–20 min daily practice; Delivery format: face to face, in person; Supplied for self practice: instructions.	Intervention: 46.1; control: 47.1	100	PSQI	Pre-intervention Post-intervention 3-month follow up
Messer et al. (2019) USA	Parallel pilot RCT	23, NR (stage I- III)	Meditation, 13	UC,10	Completed treatment; Intensity: 6 weeks, read the lessons and listen to the exercises each day; Delivery format: internet; Supplied for self practice: meditation audio clips and brief textual lesson.	NR	NR	PSQI	Pre-intervention Post-intervention
Milbury et al. (2013) USA	Parallel pilot RCT	47, breast cancer (stage I- III)	Meditation, 23	WL, 24	Completed chemotherapy and receiving hormone therapy; Intensity: 6 weeks, 2 weekly meditation classes, 60 min each class; Delivery format: face to face group; Supplied for self practice: compact disc.	Intervention: 53.0 (6.6); control: 54.1 (8.6)	100	PSQI	Pre-intervention Post-intervention 1-month follow up
Huberty et al. (2019) USA	Parallel RCT, 4 groups	128, myeloproliferative neoplasm	Meditation 10% happier APP, 33; Calm App, 32	education followed by 10% happier APP, 35education followed by Calm App, 28	NR; Intensity: 4 weeks, 10-min meditation each day; Delivery format: online APP; Supplied for self practice: online APP.	NR	NR	PROMIS	Pre-intervention Post-intervention (4 week)
Nakamura et al. (2013) USA	Parallel RCT, 3 groups	57, mixed cancer	Meditation, 20Mind-body bridging, 19	Sleep hygiene education, 18	Completed active treatment at least 3 months; Intensity: 3 weeks, 2 h each session weekly; Delivery format: face to face group; Supplied for self practice: compact disc.	Mediation: 50.8 (9.1); mind-body bridging: 55.4 (9.6); sleep hygiene education: 41.6 (10.7)	75.4	MOS-S	Pre-intervention Post-intervention 2-month follow up
Zhang et al. (2017) China	Parallel RCT	65, leukemia	Meditation, 33	UC, 32	Undergoing chemotherapy; Intensity: 5 weeks, 30–40 min session per week; Delivery format: face to face in person on the first week, self practice in the later four weeks; Supplied for self practice: NR.	Intervention: 35.64 (15.60); control: 33.58 (14.75)	44.6	PSQI	Pre-intervention Post-intervention
Kubo et al. (2019) USA	Parallel pilot RCT	97, mixed cancer	Meditation, 54	WL,43	Receiving or had received chemotherapy, targeted therapies, or immunotherapy in the prior 6 months; Intensity: 8 weeks, 10–20 min	Intervention: 59.3 (14.1); control: 56.7 (14.7)	68	PROMIS	Pre-intervention Post-intervention

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Table 1 (*continued*)

Source	Study Design	Sample size (N); population	Intervention, N	Control, N	Time point/ details of intervention	Mean Age (SD) (year)	Women (%)	Measurement of sleep health	Measured time point
					per session; Delivery format: self help via a website or mobile application; Supplied for self practice: a website or App.				
Yun et al. (2017) Korea	Parallel RCT	52, breast cancer (stage I-III)	Meditation, 26	Self-management education, 26	Completed surgery and/or adjuvant chemotherapy and/or radiotherapy; Intensity: 8 weeks, twice a week, 2 h per session; Delivery format: face to face; Supplied for self practice: NR.	48.44 (8.16)	100	PSQI	Pre-intervention Mid-intervention Post-intervention
Bower et al. (2021) USA	Parallel RCT, 3 groups	247, breast cancer (stage 0- III)	Mindfulness, 85Survivor education, 81	WL, 81	Complete surgery, radiation, and/or chemotherapy at least6 months previously; Intensity: 6 weeks, 2-hour sessions per week, 5–20 min daily practice; Delivery format: in person, face to face or online zoom; Supplied for self practice: NR.	45.4 (6.4)	100	ISI	Pre-intervention Post-interventionmonth follow up6-month follow up
Zhao et al. (2020) China	Parallel RCT	136, breast cancer (stage I- III)	MBCT, 68	WL, 68	Completed active treatment; Intensity: 6 weeks, 90-minute session per week, practice 20–40 min per day; Delivery format: face to face group; Supplied for self practice: NR.	Intervention: 52.79 (6.54); control: 53.29 (6.50)	100	ISI, actigraphy	Pre-intervention Post-intervention 3-month follow up 6-month follow up
Liu et al. (2022) China	Parallel RCT	122, hepatocellular carcinoma	MBI, 61	WL, 61	Inpatient; Intensity: 6 weeks, 5 days weekly, 20 min each day; Delivery format: self help; Supplied for self practice: audio.	Intervention: 54.36 (8.46); control: 57.02 (8.00)	22.95	PSQI	Pre-intervention Post-intervention 1-month follow up 3-month follow up
Shao et al. (2021) China	Parallel RCT	144, breast cancer (stage I-IV)	MBI, 72	WL, 72	Undergoing surgery; Intensity: 6 weeks, 5 days weekly, 20 min each day; Delivery format: self help; Supplied for self practice: audio.	42.4 (7.9)	100	AIS	Pre-intervention Post-intervention 1-month follow up 3-month follow up
Lengacher et al. (2012) USA	Parallel RCT	84, breast cancer (stage 0- III)	MBSR, 41	WL, 43	Completed treatment; Intensity: 6 weeks, 2-hour session per week, daily practice; Delivery format: face to face group; Supplied for self practice: NR.	57.5(9.4)	100	MDASI	Pre-intervention Post-intervention
Garland et al. (2014) Canada	Parallel RCT	111, mixed cancer	MBSR, 64	CBT, 47	Completed active treatments at least 1 month; Intensity: 8 weeks, 90-minute session per week and one 6-hour weekend intensive silent retreat; Delivery format: face to face group; Supplied for self practice: NR.	58.89 (11.08)	72	ISI, sleep diary, actigraph	Pre-intervention Post-intervention 3-month follow up

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Table 1 (*continued*)

Source	Study Design	Sample size (N); population	Intervention, N	Control, N	Time point/ details of intervention	Mean Age (SD) (year)	Women (%)	Measurement of sleep health	Measured time point
John et al. (2016) USA	Parallel pilot RCT	71, breast and colorectal cancer (stage 0-III)	MBSR, 35	Psycho education and support, 36	Completed treatment; Intensity: 8 weeks, 2 h each week, daily 20-minute meditation practices; Delivery format: face to face; Supplied for self practice: audio.	Intervention: 56.9 (9.9); control: 56.4 (12.7)	90.2	ISI	Pre-intervention Post-intervention 6-month follow up
John et al. (2015) USA	Parallel pilot RCT	35, mixed cancer, (stage I-IV)	MBSR, 18	WL, 17	Completed Treatment; Intensity: 7 weeks, 2-hour classes per week; Delivery format: face to face; Supplied for self practice: NR.	Intervention: 58.8 (9.3); control: 55.7 (9.3)	94.3	ISI	Pre-intervention Post-intervention 1-month follow up
Lengacher et al. (2015) USA	Parallel RCT	79, breast cancer (stage 0-III)	MBSR, 38	UC, 41	Completed active chemotherapy between 2 weeks and 2 years; Intensity: 6 weeks, 2-hour session per week, practice 15–45 min per day; Delivery format: face to face group; Supplied for self practice: compact disc.	57.0 (9.7)	100	PSQI, actigraph, sleep diary	Pre-intervention Post-intervention 6-week follow up
Witek et al. (2019) USA	Parallel RCT	164, breast cancer (stage 0-III)	MBSR, 84	Education, 80	After surgery, undergoing treatment; Intensity: 8 weeks, 2.5 h per week and a 6-hour silent mindful retreat after the fifth week; Delivery format: face to face group; Supplied for self practice: NR.	Intervention: 55.0 (10.1); control: 55.2 (10.1)	100	PSQI	Pre-intervention Mid-intervention Post-interventionmonth follow up6-month follow up
Reich et al. (2017) USA	Parallel RCT	320, breast cancer (stage 0-III)	MBSR,165	UC, 155	Completed treatment between 2 weeks and 2 years; Intensity: 6 weeks, 2-hour session per week, practice 15–45 min per day; Delivery format: face to face. Supplied for self practice: compact disc.	56.6	100	PSQI	Pre-intervention Post-intervention 1.5- month follow up
Zhang et al. (2019) China	Parallel RCT	70,cervical cancer (stage I- III)	MBSR, 35	UC, 35	Completed active treatment; Intensity: 8weeks, two-hour session each week; Delivery format: face to face group; Supplied for self practice: NR.	Intervention: 57.78 (11.12); control: 58.45 (11.08)	100	ISI, actigraph, sleep diary, polysomnography	Pre-intervention Post-intervention 6-month follow up 1-year follow up
Wirth et al. (2019) USA	Parallel RCT	36, mixed cancer	MBI, 19	Breathing control, 17	Completed treatment; Intensity: 4 weeks, practice at home; Delivery format: face to face; Supplied for self practice: NR.	63.9 (10.1)	72	PSQI, armband	Pre-intervention Post-intervention 3-month follow up
Wang et al. (2020) China	Parallel RCT	88, breast cancer (stage I- III)	MBSR, 44	UC, 44	Receiving chemotherapy after surgery; Intensity: 6 week, 2–3 h daily, practice at home; Delivery format: NR; Supplied for self practice: NR.	48.2 (9.7)	100	PSQI	Pre-intervention Post-intervention

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Table 1 (*continued*)

Source	Study Design	Sample size (N); population	Intervention, N	Control, N	Time point/ details of intervention	Mean Age (SD) (year)	Women (%)	Measurement of sleep health	Measured time point
Andersen et al. (2013) Denmark	Parallel RCT	336, breast cancer (stage I-III)	MBSR, 168	UC, 168	Receiving treatment; Intensity: 8 weeks, 2-hour sessions per week, 5-hour silent retreat after week 7, practice at home for 45 min daily; Delivery format: face to face group; Supplied for self practice: compact disc.	Intervention: 53.9 (10.1); control: 54.4 (10.5)	100	MOS-S	Pre-intervention Post-intervention 6-month follow up 12-month follow up
Blaes et al. (2016) USA	Parallel RCT	42, mixed cancer	MBCR, 28	WL, 14	Completed treatment; Intensity: 8 weeks, 2.5-hour classes and a retreat day during the second half of the 8-week program; Delivery format: face to face group; Supplied for self practice: NR.	Intervention: 55 (10); control: 57 (10)	90.5	PSQI	Pre-intervention Post-intervention 2-month follow up
Sohl et al. (2022) USA	Parallel pilot RCT	44, gastrointestinal cancer (stage II-IV)	Yoga, 23	Attention control, 21	Undergoing chemotherapy; Intensity: 8 weeks, four 30 min sessions (weeks 2, 4, 6, 8), practice four times per week at home; Delivery format: face to face in person; Supplied for self practice: an audio recording of a 16-minute yoga skills training session.	58	52	PROMIS	Pre-intervention Post-intervention 2-week follow up 6-week follow up
Taylor et al. (2018) USA	Parallel pilot RCT	26, breast cancer	Yoga, 14	WL, 12	Completed active treatment; Intensity: 8 weeks, 75 min per session, one session per week; Delivery format: face to face group; Supplied for self practice: not to practice outside of class.	Intervention: 54.9 (8.8); control: 52.6 (8.2)	100	ISI	Pre-intervention Post-intervention
Pasyar et al. (2019) Iran	Parallel pilot RCT	40, breast cancer related lymphedema (stage 0-III)	Yoga, 20	UC, 20	After breast surgery at least one year; Intensity: 8 weeks, 3 sessions each week, practice one session at home weekly; Delivery format: face to face; Supplied for self practice: digital video disc.	Intervention: 51.6 (10.46); control: 51.8 (11.4)	100	EORCT-QLQ-C30	Pre-intervention Mid-intervention Post-intervention
Rao et al. (2017) India	Parallel RCT	91, breast cancer (stage IV)	Yoga, 45	Supportive counseling, 46	Within 6 months to 2 years after diagnosis; Intensity: 12 weeks, two times per week; Delivery format: face to face, in person; Supplied for self practice: booklets and instructions.	49.6 (9.1)	100	PIRS	Pre-intervention Post-intervention
Dülger et al. (2022) Turkey	Pilot crossover RCT	10, pituitary adenoma	Yoga, 5	Aerobic and strength training, 5	after surgery; Intensity: 6 weeks, 3 consecutive days of a week, 60 min per day;	Intervention: 41.8 (14); control: 52 (13.5)	100	PSQI	Pre-intervention Post-intervention

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Table 1 (*continued*)

Source	Study Design	Sample size (N); population	Intervention, N	Control, N	Time point/ details of intervention	Mean Age (SD) (year)	Women (%)	Measurement of sleep health	Measured time point
Vadiraja et al. (2009) India	Parallel RCT	88, breast cancer (stage I- III)	Yoga, 44	Supportive counseling, 44	Delivery format: NR; Supplied for self practice: NR. Undergoing adjuvant radiotherapy; Intensity: 6 weeks, 3 sessions per week, 60 min per session, self-practice as homework on the remaining days; Delivery format: face to face, in person; Supplied for self practice: NR.	NR	100	EORCT-QLQ-C30	Pre-intervention Post-intervention
Ratcliff et al. (2016) USA	Parallel RCT, 3 groups	163, breast cancer (stage 0- III)	(1)Yoga, 53 (2)Stretch, 56	WL, 54	Undergoing Radiotherapy; Intensity: 6 weeks, three 60-minute classes per week Delivery format: face to face, in person; Supplied for self practice: an audio CD and a written manual of the program.	Yoga: 52.38 (9.83); stretch: 51.14 (9.88); WL: 52.11 (9.85)	100	PSQI	Pre-intervention Post-intervention 1-month follow up 3-month follow up 6-month follow up
Porter et al. (2019) USA	Parallel pilot RCT	63, breast cancer (metastatic)	Yoga, 43	Social support, 20	undergoing treatment; Intensity: 8 weeks, 120-minute session per week; Delivery format: face to face group; Supplied for self practice: videos.	57.3 (11.5)	100	PSQI	Pre-intervention Post-intervention 3-month follow up 6-month follow up
Lötzke et al. (2016) Germany	Parallel RCT	92, breast cancer (stage I- III)	Yoga, 45	Physical exercise, 47	Undergoing treatment; Intensity: 12 weeks, 60-minute session per week, twice 20-minutes practices a week; Delivery format: face to face group; Supplied for self practice: written instructions.	Intervention: 51.0 (11.0); control: 51.4 (11.1)	100	EORCT-QLQ-C30	Pre-intervention Post-intervention 3-month follow up
Mustian et al. (2013) USA	Parallel RCT	410, mixed cancer (stages I-IV)	Yoga, 206	UC, 204	Completed treatment; Intensity: 4 weeks, two 75-minute sessions per week; Delivery format: face to face group; Supplied for self practice: NR.	54.1 (10.11)	96	PSQI, actigraphy	Pre-intervention Post-intervention
Danhauer et al. (2009) USA	Parallel pilot RCT	44, breast cancer (stages I-IV)	Yoga, 22	WL, 22	Post surgery; Intensity: 10 weeks, 75-minute class per week; Delivery format: face to face group; Supplied for self practice: No home yoga practice.	55.8 (9.9)	100	PSQI	Pre-intervention Post-intervention
Cramer et al. (2016) Germany	Parallel RCT	54, colorectal cancer (stage I- III)	Yoga, 27	WL, 27	Post surgery; Intensity: 10 weeks, 90-min class per week, practice yoga at home daily; Delivery format: face to face group; Supplied for self practice: NR.	68.3 (9.7)	38.9	PSQI	Pre-intervention Post-intervention 3-month follow up

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Table 1 (*continued*)

Source	Study Design	Sample size (N); population	Intervention, N	Control, N	Time point/ details of intervention	Mean Age (SD) (year)	Women (%)	Measurement of sleep health	Measured time point
Chaoul et al. (2018) USA	Parallel RCT, 3 groups	227, breast cancer (stage I- III)	Yoga, 74Stretch, 68	UC, 85	Undergoing Chemotherapy; Intensity: 12 weeks, 4classes, 75–90-minutes class per 3 weeks, 3 booster session over the subsequent 6 months, practice daily; Delivery format: face to face, in person; Supplied for self practice: printed materials, audio recordings, video.	Yoga: 49.5 (9.8); stretch: 50.4 (10.3); UC: 49 (10.1)	100	PSQI, actigraphy	Pre-intervention Post-intervention 3-month follow up 6-month follow up 1-year follow up
Dhruva et al. (2012) USA	Parallel pilot RCT	18, mixed cancer	Yoga, 9	UC, 9	Undergoing chemotherapy; Intensity: 2 consecutive cycles of chemotherapy, 60-minute session per week, twice daily home practice; Delivery format: face to face in person or group; Supplied for self practice: NR.	Intervention: 52.4 (14.6); control: 56.0 (11.9)	87.5	GSDS	Pre-intervention Mid-intervention Post-intervention
Zhi et al. (2021) USA	Parallel pilot RCT	41, mixed cancer (stage I- III)	Yoga, 21	WL, 20	Completed chemotherapy at least 3 months; Intensity: 8 weeks, twice classes per week, practice 60 min per day; Delivery format: face to face group; Supplied for self practice: video.	61.9	NR	ISI	Pre-intervention Mid-intervention Post-intervention 1-month follow up
Knoerl et al. (2022) USA	Parallel pilot RCT	44, breast, colorectal, or gynecologic cancer (stage I-IV)	Yoga, 28	WL, 16	Completed chemotherapy at least 3 months; Intensity: 8 weeks, 45-minute session per week, practice at home; Delivery format:face to face or online zoom, in person ; Supplied for self practice: NR.	56.5	96	PROMIS	Pre-intervention Post-intervention
Bower et al. (2012) USA	Parallel pilot RCT	31, breast cancer (stage 0-II)	Yoga, 16	Health education, 15	Completed active treatments; Intensity: 12 weeks, 90 min twice a week; Delivery format: face to face group; Supplied for self practice: NR.	Intervention: 54.4 (5.7); control: 53.3 (4.9)	100	PSQI	Pre-intervention Post-intervention 3-month follow up
Huberty et al. (2019) USA	Parallel pilot RCT	48, myeloproliferative neoplasm	Yoga, 27	WL, 21	NR; Intensity: 12 weeks, 60 min per week; Delivery format: online; Supplied for self practice: video.	56.9 (10.3)	93.8	PROMIS	Pre-intervention Mid-intervention Post-intervention 1-month follow up
Kiecolt-Glaser et al. (2014) USA	Parallel RCT	200, breast cancer (stage 0- IIIa)	Yoga, 100	WL, 100	Completed treatment; Intensity: 12 weeks, two 90-minute sessions per week; Delivery format: face to face group; Supplied for self practice: NR.	51.6 (9.2)	100	PSQI	Pre-intervention Post-intervention 3-month follow up
Cohen et al. (2004) USA	Parallel pilot RCT	30, lymphoma (stage I-IV)	Yoga, 19	WL, 19	Receiving chemotherapy or received it within 12 months;	51	31.6	PSQI	Pre-intervention Post-intervention

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Table 1 (*continued*)

Source	Study Design	Sample size (N); population	Intervention, N	Control, N	Time point/ details of intervention	Mean Age (SD) (year)	Women (%)	Measurement of sleep health	Measured time point
					Intensity: 7 weeks, one session per week, practice at least once per day; Delivery format: face to face group; Supplied for self practice: audiotape.				1-week follow up 1-month follow up 3-month follow up
McQuade et al. (2017) USA	Parallel RCT, 3 groups	76, prostate cancer (stage I- III)	Qigong (Tai Chi), 26Light exercise, 26	WL, 24	undergoing radiotherapy; Intensity: three 40–minute classes per week throughout radiotherapy; Delivery format: face to face, in person; Supplied for self practice: digital versatile disk and printed instructional materials.	Qigong: 62.2 (7.4); light exercise: 65.0 (5.9 l); WL: 66.0 (8.4)	0	PSQI	Pre-intervention Mid-intervention Post-intervention 1-month follow up 3-month follow up
Cheung et al. (2021) China	Parallel pilot RCT, 3 groups	30, lung Cancer (Stage IIIb or IV)	Qigong (Tai Chi), 9Aerobic exercise, 10	Self management, 11	receiving treatment; Intensity: 12 weeks, 60-min sessions twice a week, 90-min self-practice each week; Delivery format: face to face; Supplied for self practice: NR.	Qigong: 61.11 (7.01); aerobic exercise: 61.00 (12.12); control: 58.36 (9.32)	46.67	PSQI, actigraph	Pre-intervention Post-intervention 6-month follow up 1-year follow up
Chen et al. (2013) China	Parallel RCT	96, breast cancer (stage 0- III)	Qigong, 49	WL, 47	Undergoing radiotherapy; Intensity: 5 or 6 weeks, five 40-minute classes each week; Delivery format: face to face group; Supplied for self practice: digital versatile disk, and printed materials.	Intervention: 45.3 (6.3); control: 44.7 (9.7)	100	PSQI	Pre-intervention Mid-intervention Post-intervention 1-month follow up 3-month follow up
Cheng et al. (2021) China	Parallel RCT, 4 groups,	120, lung, gastric and breast cancer	Qigong (Tai Chi), 30Low-intensity resistance training, 30High-intensity resistance training, 30	UC, 30	Undergoing chemotherapy and/ or radiation therapy; Intensity: 12 weeks, 3 days per week, 30 min per day; Delivery format: face to face; Supplied for self practice: NR.	NR	NR	PSQI	Pre-intervention Post-intervention
Lu et al. (2019) China	Parallel RCT	90, Colorectal cancer (stage I- III)	Qigong, 45	UC, 45	Undergoing chemotherapy; Intensity: 24 weeks,5 sessions per week, 20–40 min per session; Delivery format: face to face group; Supplied for self practice: videos.	Intervention: 55.60 (11.23); control: 54.63 (11.88)	35.63	PSQI	Pre-intervention Mid-intervention Post-intervention
Myers et al. (2019) USA	Parallel pilot RCT, 3 groups	50, breast cancer (stage I- III)	Qigong, 19 Gental exercise,20	Survivor ship support, 11	Completed active treatment; Intensity: 8 weekly 60-min sessions, practice 15 min at home twice a day; Delivery format: face to face group; Supplied for self practice: NR.	53.68	100	MDASI	Pre-intervention Post-intervention 4-week follow up
Larkey et al. (2015) USA	Parallel RCT	101, breast cancer (stage 0- III)	Qigong (Tai chi), 49	Exercise, 52	Completed treatment; Intensity: 12 weeks, 60 min per session, practice at home at least 30 min a day, 5 days per week;	58.8 (8.94)	100	PSQI	Pre-intervention Post-intervention 3-month follow up

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Table 1 (*continued*)

Source	Study Design	Sample size (N); population	Intervention, N	Control, N	Time point/ details of intervention	Mean Age (SD) (year)	Women (%)	Measurement of sleep health	Measured time point
Irwin et al. (2017) USA	Parallel RCT	90, breast cancer	Qigong (Tai ch Chihi), 45	CBT, 45	Delivery format: face to face; Supplied for self practice: NR. Completed treatment at least 6 months; Intensity: 3 months, 120-minute sessions per week; Delivery format: face to face group; Supplied for self practice: NR.	Intervention: 59.6 (7.9); control: 60.0 (9.3)	100	PSQI, sleep diary, polysomnography	Pre-intervention Post-intervention 3-month follow up 1-year follow up
Oh et al. (2008) Australia	Parallel pilot RCT	30, heterogeneous cancers	Qigong, 15	UC, 15	Completed cancer treatment or under chemotherapy; Intensity: 8 weeks, once or twice a week, practice at home every day; Delivery format: face to face group; Supplied for self practice: NR.	54 (9)	75	EORTC-QLQ-C 30	Pre-intervention Post-intervention
Vanderbyl et al. (2017) Canada	Cross-over RCT	24, non-small cell lung and gastrointestinal cancers (stage: III- IV)	Qigong, 11	Standard care and strength training, 13	Receiving anti-cancer treatment; Intensity: 6 weeks, twice sessions per week, 45 min per session; practice 1 h every day at home; Delivery format: face to face group; Supplied for self practice: NR.	Intervention: 66.1 (11.7); control: 63.7 (7.7)	41.7	Patient-rated symptom questionnaire	Pre-intervention Post-intervention
Yeh et al. (2016) Taiwan	Parallel RCT	108, non-Hodgkin's lymphoma	Qigong, 54	UC, 54	Undergoing chemotherapy; Intensity: 21 days, 20 min per day; Delivery format: face to face, in person; Supplied for self practice: Guidance booklets.	59.79 (16.54)	44.1	VHSSS	Pre-intervention Post-intervention
Yang et al. (2010) China	Parallel RCT, 3 groups	90, nasopharyngeal carcinoma	Relaxation, 30; Calligraphy, 30	NR (probably UC), 30	Undergoing radiotherapy; Intensity: 4 weeks, 30 min per day; Delivery format: face to face; Supplied for self practice: NR.	49.63 (10.81)	32.2	SDS	Pre-intervention Mid-intervention Post-intervention 2-week follow up
Cohen et al. (2007) Isreal	Parallel RCT, 3 groups	114, breast cancer (Stages I-II)	RGI, 39; CBT, 38	UC, 37	Undergoing chemotherapy/ radiotherapy; Intensity: 9 weeks, 90-minute per session each week; Delivery format: face to face group; Supplied for self practice: NR	RGI: 51.8 (11.6); CBT: 55.9 (10.4); UC: 52.9 (11.8)	100	MSQ	Pre-intervention Post-intervention 4-month follow up
Loh et al. (2022) Taiwan	Parallel RCT	68, head and neck cancer	PMR, 34	UC, 34	Perioperative period; Intensity: 7 days,15 min per day; Delivery format: led by MP3 file; Supplied for self practice: MP3 file.	55.4 (11.8)	11.8	VAS	Pre-intervention Post-intervention
Ducloux et al. (2013) Switzerland	Parallel pilot RCT	18, mixe cancer (stage: metastatic)	Relaxation, 9	UC, 9	Receiving palliative care; Intensity: 3 days, 1 h training session per day; Delivery format: face to face; Supplied for self practice: compact disc.	Intervention: 61 (15); control: 66 (12)	66.7	NRS	Pre-intervention Post-intervention

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Table 1 (*continued*)

Source	Study Design	Sample size (N); population	Intervention, N	Control, N	Time point/ details of intervention	Mean Age (SD) (year)	Women (%)	Measurement of sleep health	Measured time point
Steindorf et al. (2017) Germany	Parallel RCT	160, breast cancer (stage: 0-III+)	PMR, 80	Progressive resistance exercises, 80	Receiving radiotherapy; Intensity: 12 weeks, twice session weekly, 60 min per session; Delivery format: face to face group; Supplied for self practice: NR.	55.6 (9.0)	100	EORTC-QLQ-C30	Pre-intervention Post-intervention
Harorani et al. (2020) Iran	Parallel RCT	84, mixed cancer	Relaxation, 42	UC, 42	Undergoing chemotherapy; Intensity: 5 days, twice a day; Delivery format: face to face and audio file; Supplied for self practice: audio file.	Intervention: 45.8 (12.1); control: 45.1 (12.9)	50	SMHSQ	Pre-intervention Post-intervention
Knoerl et al. (2022) USA	Parallel RCT	47, breast cancer (stage I- III)	Relaxation, 21	Aerobic and resistance exercise training, 26	Before surgery; Intensity: mean 28.9 days, twice a day; Delivery format: self help; Supplied for self practice: a book and a imagery relaxation audio guide.	52.8 (8.8)	100	EORTC-QLQ-C-30	Pre-intervention Post-intervention 1-month follow up
Charalambous et al. (2016) Cyprus	Parallel RCT	236, breast and prostate cancer (stage: T3N1M0 or T3a)	PMR, 120	UC, 116	Undergoing Chemotherapy Intensity: 4 weekly supervised sessions, daily unsupervised sessions led by compact disc; Delivery format: face to face, compact disc; Supplied for self practice: compact disc.	NR	50	EORTC-QLQ-C30	Pre-intervention Post-intervention
Nooner et al. (2016) USA	Parallel pilot RCT, 4 groups	12, hematologic malignancies or solid tumor,	Relaxation, 3;Guide imagery, 3; Relaxation and guide imagery, 3	UC, 3	Receiving chemotherapy or prior to hematopoietic stem cell transplantation; Intensity: 30 days; Delivery format: MP3; Supplied for self practice: audio recording.	41	45.5	PROMIS	Pre-intervention Post-intervention 1-month follow up
Carnahan et al. (2010) USA	Parallel pilot RCT	28, mixed cancer (stage I-IV)	Hypnosis, 14	WL, 14	Completed active treatment; Intensity: 4 weeks, listening to recordings at least 16 times, at least 6 h; Delivery format: self-hypnosis recordings; Supplied for self practice: recordings.	56.7 (11.7)	85.7	ISI, sleep diary	Pre-intervention Post-intervention
Elkins et al. (2008) USA	Parallel RCT	60, breast cancer	Hypnosis, 30	UC, 30	Completed active treatment; Intensity: 5 weekly sessions, 50 min per session; Delivery format: face to face and tape recording; Supplied for self practice: recordings.	Intervention: 55; control: 58	100	MOS-S	Pre-intervention Post-intervention
Freeman et al. (2015) USA	Parallel RCT, 3 groups	118, breast cancer	Live delivery Imagery, 48;tele-de-livery imagery, 23	WL, 47	Completed major treatments at least 6 weeks; Intensity: 5 weeks, 4-hour sessions per week; Delivery format: face to face	Live delivery: 55.44 (8.08); tele- delivery: 55.57 (9.88); WL: 55.28 (7.90)	100	PSQI	Pre-intervention Post-intervention 2-month follow up

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Table 1 (*continued*)

Source	Study Design	Sample size (N); population	Intervention, N	Control, N	Time point/ details of intervention	Mean Age (SD) (year)	Women (%)	Measurement of sleep health	Measured time point
					group or video group; Supplied for self practice: 20–30 minute of guided imagery compact disc.				
Stoerkel et al. (2018) USA	Parallel RCT	100, breast cancer (stage 0- III)	Mixed mind-body skills, 51	UC, 49	Receiving surgery, pre- and post-operative periods; Intensity: 2 weeks, read the manual and listen to each of the seven audio-files at least once, including breathing, relaxation, meditation, guided imagery, and self-hypnosis suggestions; Delivery format: self help; Supplied for self practice: audio-files.	NR	100	PROMIS	Pre-intervention Post-intervention 2-week follow up

Active treatment, including surgery, chemotherapy and radiotherapy (if received), excluded hormonotherapy or endocrine therapy

CBT, cognitive behavior therapy for insomnia; MBI, mindfulness-based intervention; MBCT, mindfulness-based cancer recovery; MBSR, mindfulness-based stress reduction; NR, not report, PMR, progressive muscle relaxation; RGI, relaxation with guided imagery;UC, usual care; WL, wait list; AIS, Athens Insomnia Scale; EORTC-QLQ-C30, European Organization for Research and Treatment of Cancer Quality of Life Questionnare-Core 30; GSDS, General Sleep Disturbance Scale; ISI, Insomnia Severity Index; MDASI, MD Anderson Cancer Symptom Inventory; MOS-S, Medical Outcomes Study Sleep Scale; MSQ, Mini Sleep Questionnaire; NRS, Numerical Rating Scale; PIRS, Pittsburgh Insomnia Rating Scale; PROMIS, Patient-Reported Outcomes Measurement System; PSQI, Pittsburgh Sleep Quality Index; SDS, Symptom Distress Scale; SMHSQ, St. Mary's Hospital Sleep Questionnaire; VAS, Visual Analog Scale; VHSSS, Verran and Snyder-Halpern Sleep Scale.

completion, and palliative care reception. The intervention intensity peaked from 3 days to 24 weeks, and 66% (45/66) of studies reported maximum intervention intensity at 4–8 weeks. Fifty-three studies conducted face-to-face interventions, 11 studies used online or audio files, 2 studies combined face-to-face and online interventions, and 2 studies did not report intervention delivery formats. Sixty-six studies encouraged participants to practice MBTs on their own, and 35 studies supplied written instruction materials, audio files, or videos. Two yoga studies did not allow participants to practice on their own.[32,33]

All 68 studies reported subjective sleep disturbance using self-rating questionnaires, such as the PSQI (n = 30), ISI (n = 7), sleep-related item of EORTC-QLQ-C30 (n = 7), sleep-related item of PROMIS (n = 7), and other rating scales (n = 7) (Table 1). For most questionnaires, the higher the score, the more serious the sleep disturbance. Only the Verran and Snyder-Halpern Sleep Scale score had an opposite interpretation with respect to sleep disturbance.[34] Ten studies reported objective sleep outcomes using actigraphy (n = 8), sleep diary (n = 5), polysomnography (n = 2), and armband (n = 1). The follow-up time ranged

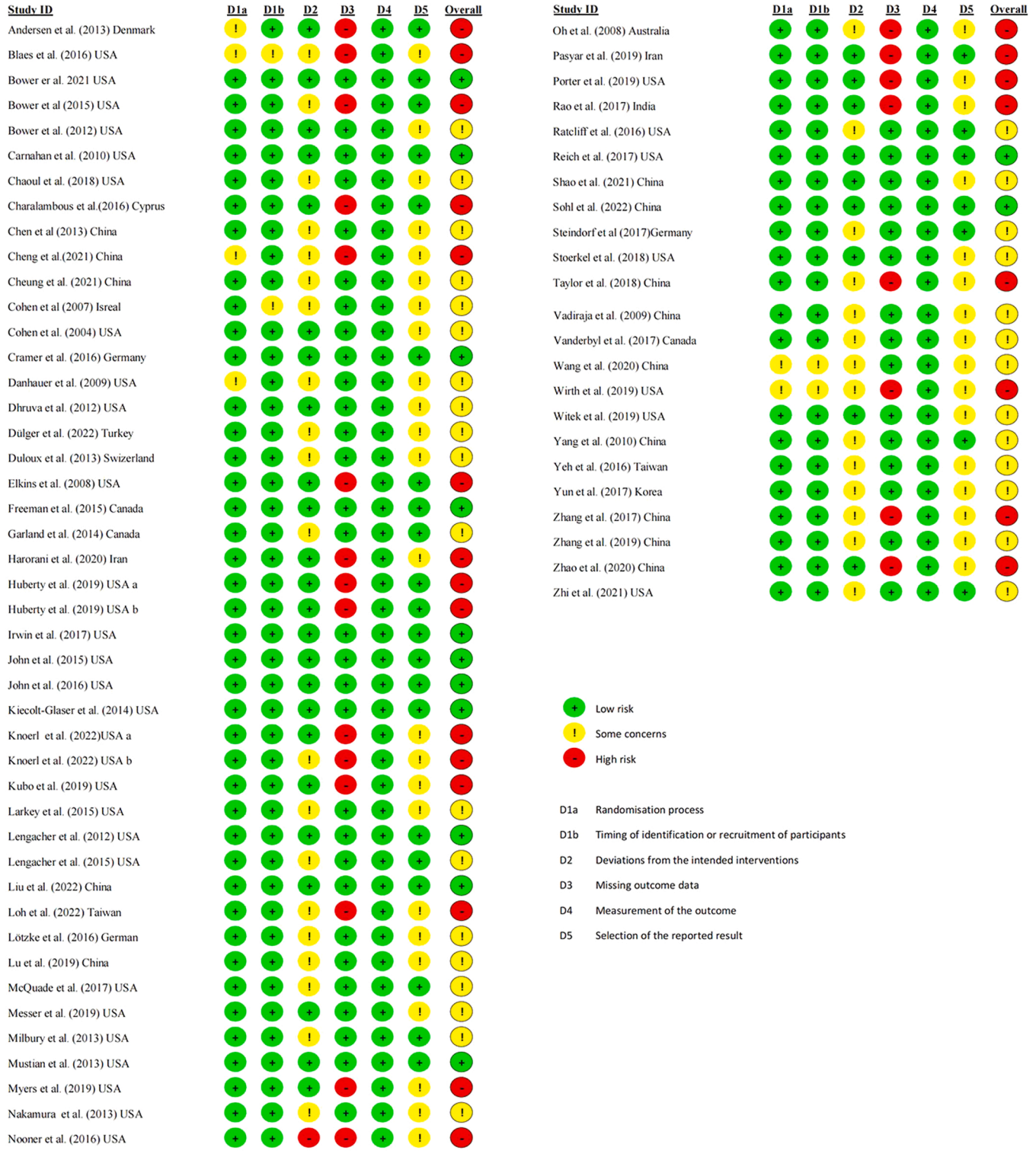

Fig. 2. Risk of bias summary.

from 2 weeks to 12 months.

3.3. Risk of bias

The summary of the risk of bias of the 68 studies is presented in Fig. 2. Sixty-two and 64 studies provided sufficient evidence regarding the randomization process and the timing of participant identification or recruitment, which were rated as having a low risk for randomization; 6 and 4 studies failed to report details about the randomization process or the timing of participant identification or recruitment which were rated as having some concerns. Thirty-three studies were rated as having low risks of deviations from the intended intervention because checklists, intervention records, and supervision were used for evaluating fidelity; 34 studies did not report the process of intervention clearly and were rated as having some concerns; 1 study did not report the process of intervention and was rated as having high risks. Forty-five studies were rated as having low risks of missing outcome data because enough information on missing data was reported, while 23 studies were rated as having high risks for not reporting the information on missing data. All subjective sleep measurements were performed using patient self-filled questionnaires, and all objective sleep variables were obtained using credible instruments, which were not affected by outcome assessors. All 68 studies were rated as having low risks of outcome measurement. Twenty-eight study protocols or registers were available to assess the selection of the reported results, which were rated as having a low risk at the selective reporting domain, and the other 40 studies were rated as having some concerns. Based on the judgment of risk of bias on selected key domains, 13, 23, and 32 studies were assessed as having low, high, and unclear risks of bias, respectively.

3.4. Meta-analysis

Fifty-six studies (5051 participants) were included in the meta-analysis, and their data were extracted to evaluate the association of MBTs with sleep disturbance. The remaining 12 studies were excluded for the following reasons: mean or SD not available,[35–38] mean change from baseline only,[39,40] follow-up data mixed,[41,42] reported only categorical data,[43] results not representing sleep disturbance,[34] included only one imaging study,[44] and included mixed mind-body interventions.[45] Among the 56 RCTs, 37 studies had UC/WL control groups, and 26 studies had active control groups. The funnel plot showed some publication bias (Supplementary Fig. S1).

3.4.1. Mindfulness or meditation studies

3.4.1.1. Effectiveness of mindfulness on subjective sleep disturbance, compared with UC/WL interventions. Fifteen studies conducted on mindfulness or meditation were compared with UC/WL intervention studies reporting subjective sleep disturbance, and the intensity of the intervention peaked at 6–8 weeks.[46–60] The mindfulness interventions included MBSR (n = 6), meditation (n = 5), MBI (n = 3), and MBCT (n = 1). The results of the meta-analysis are shown in Table 2 and Supplementary Fig. S2.

Nine[46–51,56–58] of the 15 studies[46–60] (60%) reported statistically significant immediate effects. Meta-analysis results showed a significant immediate effect, with high heterogeneity. After excluding two studies[55,59] in which the baseline PSQI scores were statistically different, meta-analysis results showed a significant immediate effect, with high heterogeneity. Subsequently, we excluded five studies with highly positive results[47,51,56–58], and the effect remained statistically significant (SMD = −0.26, 95% CI: −0.41 to −0.10, $p = 0.00$), with low heterogeneity ($Chi^2 = 14.39$, $I^2 = 37\%$, $p = 0.11$).

Three[48,49,52] of the six studies[48,49,52,54,55,59] (50%) reported statistically significant short-term effects. Meta-analysis results showed no significant short-term effect, with high heterogeneity. After excluding two studies in which the baseline PSQI scores were statistically different[55,59], meta-analysis results showed a significant short-term effect (SMD = −0.47, 95% CI: −0.73 to −0.21, $p = 0.00$), with low heterogeneity ($Chi^2 = 4.36$, $I^2 = 31\%$, $p = 0.23$).

Five[46–48,50,52] of the six studies[46–48,50,52,56] (83%) reported statistically significant mid-term effects. Meta-analysis results showed a significant mid-term effect, with high heterogeneity. After excluding two studies with highly positive results[47,50], the effect remained statistically significant (SMD = −0.47, 95% CI: −0.65 to −0.30, $p = 0.00$), with low heterogeneity ($Chi^2 = 2.81$, $I^2 = 0\%$, $p = 0.42$).

All three studies[46,47,50] (100%) reported statistically significant long-term effects. Meta-analysis results showed a significant long-term effect ($p = 0.00$), although the heterogeneity was high.

3.4.1.2. Effectiveness of mindfulness on subjective sleep disturbance, compared with active control. Seven studies conducted on mindfulness were compared with active control intervention studies reporting subjective sleep disturbance, and the intensity of the intervention peaked at 3–8 weeks.[46,61–66] The mindfulness interventions included MBSR (n = 3), meditation (n = 2), and MBI (n = 2). The active control interventions included breathing control, education, and CBT. Meta-analysis results are shown in Table 3 and Supplementary Fig. S3.

One[46] of the seven studies[46,61–66] (14%) reported a statistically significant immediate effect. Meta-analysis results showed no significant effect, with high heterogeneity. After excluding the study with highly negative results[61], which compared MBSR with CBT, the effect was statistically significant (SMD = −0.32, 95% CI: −0.49 to −0.15, $p = 0.00$), with low heterogeneity ($Chi^2 = 3.45$, $I^2 = 0\%$, $p = 0.63$).

One[66] of the two studies[63,66] (50%) reported a statistically significant short-term effect. The active control was education. Meta-analysis results showed no significant effect ($p = 0.09$).

Table 2
Meta-analysis results of subjective sleep disturbance (MBTs vs UC/WL).

Variables (sample sizes, intervention / control)	Subjective sleep disturbance			Heterogeneity		
	SMD	95%CI	p	Chi^2	I^2 (%)	p
Mindfulness						
Immediate effect (773 / 747)	-0.74	-1.10, − 0.37	0.00	157.09	91	0.00
Short-term effect (377 / 370)	-0.27	-0.57, 0.03	0.08	17.50	71	0.00
Mid-term effect (360 / 349)	-0.75	-1.13, − 0.38	0.00	28.56	82	0.00
Long-term effect (188 / 184)	-0.94	-1.54, − 0.34	0.00	14.27	86	0.00
Yoga						
Immediate effect (425 / 416)	-0.21	-0.35, − 0.08	0.00	7.01	0	0.72
Short-term effect (96 / 94)	0.10	-0.21, 0.40	0.53	2.21	10	0.33
Mid-term effect (143 / 151)	-0.15	-0.47, 0.17	0.36	3.68	46	0.16
Long-term effect (100 / 114)	0.10	-0.17, 0.37	0.45	0.15	0	0.70
Qigong						
Immediate effect (143 / 145)	-0.77	-1.71, 0.16	0.11	41.35	93	0.00
Short-term effect (70 / 71)	0.24	-0.09, 0.57	0.15	0.07	0	0.79
Mid-term effect (70 / 71)	0.23	-0.10, 0.56	0.18	0.30	0	0.59
Relaxation						
Immediate effect (147 / 147)	-0.82	-1.32, − 0.32	0.00	15.98	75	0.00
Hypnosis						
Immediate effect (41 / 38)	-1.21	-2.14, − 0.29	0.01	3.44	71	0.06

SMD, standardized mean differences.

Table 3
Meta-analysis results of subjective sleep disturbance (MBTs vs active control).

Variables (sample sizes, intervention / control)	Subjective sleep disturbance			Heterogeneity		
	SMD	95%CI	p	Chi^2	I^2 (%)	p
Mindfulness						
Immediate effect (301 / 314)	-0.12	-0.49, 0.24	0.51	27.64	78	0.00
Short-term effect (104 / 98)	-0.34	-0.73, 0.05	0.09	1.44	30	0.23
Mid-term effect (136 / 138)	0.00	-0.75, 0.75	1.00	15.68	87	0.00
Long-term effect (204 / 197)	-0.20	-0.45, 0.05	0.12	3.13	36	0.21
Yoga						
Immediate effect (324 / 287)	-0.29	-0.58, 0.00	0.05	23.18	65	0.00
Short-term effect (76 / 77)	-0.07	-0.39, 0.24	0.65	0.23	0	0.63
Mid-term effect (220 / 193)	-0.13	-0.42, 0.16	0.39	8.24	51	0.08
Long-term effect (143 / 115)	0.00	-0.25, 0.25	1.00	0.64	0	0.73
Qigong						
Immediate effect (166 / 163)	0.03	-0.38, 0.43	0.90	15.15	67	0.01
Short-term effect (40 / 32)	0.28	-0.19, 0.75	0.24	0.06	0	0.81
Mid-term effect (108 / 111)	-0.04	-0.38, 0.31	0.84	3.24	38	0.20
Long-term effect (54 / 56)	0.15	-0.23, 0.52	0.44	0.31	0	0.58
Relaxation						
Immediate effect (168 / 171)	-0.08	-0.67, 0.52	0.80	20.42	85	0.00
Short-term effect (51 / 56)	-0.47	-1.33, 0.39	0.29	4.84	79	0.03

SMD, standardized mean differences.

Table 4
Meta-analysis results of objective sleep disturbance.

Variables (sample sizes, intervention / control)	Subjective sleep disturbance			Heterogeneity		
	WMD	95%CI	p	Chi^2	I^2 (%)	p
Mindfulness*						
SE (141 / 144)	1.09	-2.93, 5.12	0.59	15.60	87	0.00
WASO (106 / 109)	-4.44	-31.77, 22.90	0.75	23.43	96	0.00
SOL (106 / 109)	-5.21	-8.70, − 1.73	0.00	0.19	0	0.66
TST (141 / 144)	13.94	3.47, 24.41	0.01	0.24	0	0.89
Yoga*						
SE (231 / 232)	0.61	-0.70, 1.93	0.36	0.03	0	0.85
WASO (231 / 232)	-4.87	-8.57, − 1.17	0.01	0.03	0	0.86
SOL (231 / 232)	1.37	-6.24, 8.99	0.72	2.87	65	0.09
Qigong* *						
SE (54 / 56)	1.61	-1.00, 4.22	0.23	1.01	1	0.32
TST (54 / 56)	3.49	-15.09, 22.08	0.71	0.03	0	0.86

* vs UC/WL; * *, vs active control; TST, total sleep time; SE, sleep efficiency; WASO, wake after sleep onset; SOL, sleep onset latency; WMD, weighted mean difference.

One[46] of the three studies[46,61,64] (33%) reported a statistically significant mid-term effect. The active controls were breathing control, education, and CBT. Meta-analysis results showed no significant effect, with high heterogeneity. After excluding a study with positive results[46], which compared MBI with education, the effect remained non-statistically significant (SMD = 0.39, 95% CI: 0.00–0.77, $p = 1.00$), with low heterogeneity ($Chi^2 = 0.91$, $I^2 = 0\%$, $p = 0.34$).

All three studies[46,62,63] reported no statistically significant long-term effect. The active control was education. Meta-analysis results showed no significant effect ($p = 0.12$).

3.4.1.3. Effectiveness of mindfulness on objective sleep outcomes, compared with UC/WL. Three studies[47,50,54] conducted on mindfulness were compared with UC/WL intervention studies reporting objective sleep disturbance at post-intervention, including SE, WASO, SOL, and TST. The interventions included MBSR (n = 2) and MBCT (n = 1), and the intensity of the intervention peaked at 6–8 weeks. Meta-analysis results showed no significant immediate effect on SE, with high heterogeneity. After excluding a study with highly positive results[47], the effect remained non-statistically significant (SMD = −0.84, 95% CI: −3.14 to 1.46, $p = 0.60$), with low heterogeneity ($Chi^2 = 0.02$, $I^2 = 0\%$, $p = 0.90$). Meta-analysis results showed no significant immediate effect on WASO ($p = 0.75$), with high heterogeneity. However, significant immediate effects of mindfulness on SOL ($p = 0.00$) and TST ($p = 0.01$) were demonstrated. (Table 4 and Supplementary Fig. S4 [A–D]).

3.4.2. Yoga studies

3.4.2.1. Effectiveness of yoga on subjective sleep disturbance, compared with UC/WL. Eleven studies[32,33,67–75] conducted on yoga were compared with UC/WL intervention studies reporting subjective sleep disturbance, and the intensity of the intervention peaked at 4–12 weeks. Four[33,67,69,75] of the 11 studies[32,33,67–75] (36.4%) reported statistically significant immediate effects; one[75] of the three studies[68,73,75] (33.3%) reported statistically significant short-term effect; one[71] of the three studies[68,71,72] (33.3%) reported statistically significant mid-term effect; all the two studies[68,72] reported no statistically significant long-term effect. Meta-analysis results showed a significant immediate effect ($p = 0.00$) and no significant short- ($p = 0.53$), mid- ($p = 0.36$), or long-term ($p = 0.45$) effect. (Table 2 and Supplementary Fig. S2).

3.4.2.2. Effectiveness of yoga on subjective sleep disturbance, compared with active control. Nine studies conducted on yoga were compared with active control intervention studies reporting subjective sleep disturbance, and the intensity of the intervention was peaked at 6–12 weeks.[68,72,76–82] The active control interventions included attention control, supportive counseling, aerobic and strength training, stretching, social support, physical exercise, and health education. Three[68,76,77] of the nine studies[68,72,76–82] (33.3%) reported statistically significant immediate effects. Meta-analysis results showed no significant immediate effect, with high heterogeneity. After excluding a study with highly positive results[76], which compared yoga with supportive counseling, the effect remained non-statistically significant (SMD = −0.19, 95% CI: −0.40 to 0.03, $p = 0.05$), with low heterogeneity ($Chi^2 = 10.01$, $I^2 = 30\%$, $p = 0.19$). Neither of the two studies[68,82] reported a statistically significant short-term effect. Two[80,81] of the four studies[68,72,78,80,81] (50%) reported statistically significant mid-term effects. All three studies reported no statistically significant long-term effect.[68,72,81] Meta-analysis results showed no statistically significant short- ($p = 0.65$), mid- ($p = 0.39$), or long-term ($p = 1.00$) effect (Table 3 and Supplementary Fig. S3).

3.4.2.3. Effectiveness of yoga on objective sleep outcomes, compared with UC/WL. Two studies conducted on yoga were compared with UC/WL intervention studies reporting objective sleep disturbance, including SE, WASO, and SOL, and the intensity of the intervention peaked at 4 or 7 weeks.[59,72] Meta-analysis results showed a significant immediate effect on WASO ($p = 0.01$) and no immediate effect on SE ($p = 0.36$) and SOL

($p = 0.72$). (Table 4 and Supplementary Fig.S4 [E–G]).

3.4.3. Qigong studies

3.4.3.1. Effectiveness of qigong on subjective sleep outcomes, compared with UC/WL. Four studies conducted on qigong were compared with UC/WL intervention studies reporting subjective sleep disturbance, and the intensity of the intervention peaked at 6–24 weeks.[83–86] The interventions included qigong (n = 2) and taichi (n = 2). Two[83,84] of the four studies[83–86] (50%) reported statistically significant immediate effects. Meta-analysis results showed no statistical significance, with high heterogeneity. After excluding two studies with highly positive results[83,84], the effect remained non-statistically significant (SMD = 0.02, 95% CI: −0.38 to 0.42, $p = 0.10$), with low heterogeneity ($Chi^2 = 1.37$, $I^2 = 27\%$, $p = 0.24$). Both studies[85,86] (100%) reported no significant short- or long- term effect, and meta-analysis results showed no significant effect ($p > 0.10$). (Table 2 and Supplementary Fig. S2).

3.4.3.2. Effectiveness of qigong on subjective sleep outcomes, compared with active control. Six studies conducted on qigong were compared with active control intervention studies reporting subjective sleep disturbance, and the intensity of the intervention peaked at 8–12 weeks.[83,85,87–90] The interventions included qigong (n = 1) and taichi (n = 5). The active control interventions included exercise, resistance training, education, survivorship support, and CBT. One[83] of the six studies[83,85,87–90] (16.7%) reported a statistically significant immediate effect. Meta-analysis results showed no effect, with high heterogeneity. After excluding a study with highly positive results[83], which compared qigong with resistance training, the effect remained non-significant (SMD = 0.18, 95% CI: −0.06 to 0.43, $p = 0.90$), with low heterogeneity ($Chi^2 = 3.34$, $I^2 = 0\%$, $p = 0.50$). Neither of the two studies[85,88] reported a statistically significant short-term effect. All three studies reported no statistically significant mid-term effect.[85,89,90] Neither of the two studies[87,90] reported a statistically significant long-term effect. Meta-analysis results showed no statistically significant short- ($p = 0.24$), mid- ($p = 0.84$), or long-term ($p = 0.44$) effect. (Table 3 and Supplementary Fig. S3).

3.4.3.3. Effectiveness of qigong on objective sleep outcomes, compared with active control. Two studies conducted on qigong were compared with active control intervention studies reporting objective sleep disturbance, including SE and TST.[87,90] The intervention was taichi (n = 2), and the intensity of the intervention peaked at 12 weeks. The active control interventions included self-management education and CBT. Meta-analysis results showed no significant immediate effect on SE ($p = 0.23$) and TST ($p = 0.71$). (Table 4 and Supplementary Fig. S4 [H, I]).

3.4.4. Relaxation studies

3.4.4.1. Effectiveness of relaxation on subjective sleep outcomes, compared with UC/WL. Five studies conducted on relaxation were compared with UC/WL intervention studies reporting subjective sleep disturbance.[91–95] The interventions included relaxation (n = 3), relaxation with guided imagery (n = 1), and progressive muscle relaxation (n = 1). The intensity of the intervention peaked at 3 days to 9 weeks. Three[91–93] of the five studies[91–95] (60%) reported statistically significant immediate effects of relaxation on subjective sleep disturbance. Meta-analysis results showed a significant effect, with high heterogeneity. After excluding two studies with highly positive results[92,93], the effect was statistically significant (SMD = −0.51, 95% CI: −1.14 to −0.12, $p = 0.00$), and the heterogeneity remained high ($Chi^2 = 6.45$, $I^2 = 69\%$, $p = 0.04$). Meta-analysis was not conducted because only one study reported short-[94] and mid-term[91] data. (Table 2 and Supplementary Fig. S2).

3.4.4.2. Effectiveness of relaxation on subjective sleep outcomes, compared with active controls. Four studies conducted on relaxation were compared with active control intervention studies reporting subjective sleep disturbance.[91,94,96,97] The interventions included relaxation (n = 3) and progressive muscle relaxation (n = 1). The intensity of the intervention peaked at 4–12 weeks. The active control interventions included exercise (n = 2), CBT (n = 1), and calligraphy (n = 1). One[94] of the four studies[91,94,96,97] (25%) reported a statistically significant immediate effect. Meta-analysis results showed no immediate effect ($p = 0.80$), with high heterogeneity, which remained high ($I^2 > 50\%$) after we excluded any of the four studies. All the two studies[94,97] reported no statistically significant short-term effect. Moreover, meta-analysis results showed no significant short-term effect ($p = 0.29$), with high heterogeneity. (Table 3 and Supplementary Fig. S3).

3.4.5. Hypnosis studies

Two studies conducted on hypnosis were compared with UC/WL intervention studies reporting subjective sleep disturbance.[98,99] One[98] of the two studies.[98,99] (50%) reported a statistically significant immediate effect. Meta-analysis results showed a significant effect ($p = 0.01$), with high heterogeneity. (Table 2 and Supplementary Fig. S2).

3.5. Studies not included in the meta-analysis

Among the 12 studies in this systematic review that were excluded from the meta-analysis, 2, 2, 3, 2, 1, 1, and 1 studies assessed yoga,[41,42] mindfulness,[37,38] qigong,[34,36,40] relaxation,[35,39] meditation,[43] imagery,[44] and mixed mind-body intervention,[45] respectively. These studies had the following outcome results. The two parallel RCTs on yoga concluded that, compared with WL control, the interventions were effective in improving sleep after treatment,[41,42] which was in accordance with the findings of previous meta-analyses on yoga. The two remaining studies wherein mindfulness was compared with UC or WL control, showed evidence of improved sleep quality; one study concluded that mindfulness-based cancer recovery produced sustained improvements in sleep quality until 4 months after intervention completion,[38] whereas the other study concluded that MBSR was effective in decreasing sleep disturbance after treatment;[37] furthermore, there was no sustainable effect at the 6- and 12-month follow-ups. Mindfulness studies not included in the meta-analysis reported similar results to those of the meta-analyzed studies. The three studies on qigong obtained contrasting results; two studies on medical qigong[36,40] showed no significant results, whereas one study on qigong[34] concluded that the interventions were effective in sleep improvement after treatment. Qigong studies not included in the meta-analysis reported similar results to those of the meta-analyzed qigong studies. For relaxation plus guided imagery, one parallel RCT with 236 participants showed evidence for the reduction in the severity of insomnia after treatment,[39] and one pilot and feasibility study with three participants in each group only reported the data of individuals.[35] The findings of these two studies were in accordance with those of the meta-analyses, which could not conclude the effect of relaxation on sleep disturbance. The study on meditation[43], compared with self-management education, showed significant differences in sleep quality changes after treatment, which was in accordance with the meta-analysis findings. The study on imagery[44], compared with WL, showed significant differences in subjective sleep disturbance changes after treatment. The study on mixed mind-body intervention among perioperative patients with cancer[45], compared with WL, showed no significant differences in subjective sleep disturbance changes after treatment.

4. Discussion

4.1. Summary of main results

This is the first systematic review that examined the effect of MBTs

on subjective and objective sleep disturbance in patients with cancer. Compared with UC or WL control, the meta-analysis results showed a significant immediate effect of four MBTs on subjective sleep disturbance, including mindfulness, yoga, relaxation, and hypnosis; the effect of mindfulness lasted at least 6 months. For objective sleep outcomes, the meta-analysis results showed a significant immediate effect of yoga on WASO and of mindfulness on SOL and TST. Compared with the active control intervention, this meta-analysis did not find any effect of MBTs on subjective sleep disturbance.

4.2. Agreements and disagreements with other studies or reviews

In this study, we included 24 RCTs on mindfulness, and the interventions included MBSR, MBCT, meditation, and MBI. The interventions in 20 RCTs lasted 6–8 weeks. After excluding the two studies[55,59] in which the baseline PSQI scores were statistically different, compared with UC or WL control, the meta-analysis results showed sustainable effects of mindfulness on subjective sleep disturbance, and the effect lasted at least 6 months. Moreover, mindfulness had an immediate effect on SOL and TST. Compared with active control, the absence of an effect of mindfulness on subjective sleep disturbance was particularly striking, given that the active control intervention included CBT. After excluding CBT, meta-analysis results showed significant immediate effects of mindfulness on subjective sleep disturbance, compared with breath control and education. Mindfulness may be the most studied type of meditation for patients with cancer. Meditation involves a series of techniques that intentionally train the mind on awareness and attention.[100] Previous reviews have reported that mindfulness could significantly improve subjective sleep quality in patients with cancer, compared with controls; nevertheless, the comparative group underwent a combination of interventions including UC, WL, and active control interventions.[18,101] These findings suggested that mindfulness could be another treatment option for sleep disturbance in patients with cancer.

We included 20 yoga RCTs in this systematic review and found that, compared with UC or WL controls, yoga had immediate effects on subjective sleep disturbance and WASO. Compared with active control interventions, such as attention control, aerobic and strength training, counseling, and social support, yoga showed no effect on sleep disturbance. In a meta-analysis of two studies, Yi et al.[19] found the immediate effects of yoga on sleep disturbance in patients with breast cancer. Yoga incorporates physical postures, breathing exercises, meditation, chants, and relaxation, which emphasizes the mind, body, and spirit flowing in perfect harmony with nature.[102] Because yoga requires extensive muscle and whole-body exercises, participants were not allowed to practice on their own in two included yoga studies.[32,33] This suggested that patient physical function assessment is required before and during yoga interventions. Future research should identify strategies to maintain the effects of yoga, such as training supplements to sustain patient motivation to practice.

Eight qigong studies were included in this meta-analysis and did not observe an effect on sleep disturbance, compared with either control intervention (six and four RCTs wherein qigong was compared with active control and UC/WL control interventions, respectively). Qigong and taichi are both based on theoretical principles that are inherent to traditional Chinese medicine, which involves slow-flowing physical movements coordinated with breathing, stretching, relaxation, mental focus on movement sense, and a meditative mind.[103] In the literature, these two forms of therapy are suggested to involve one body of evidence.[21] Results of previous systematic reviews related to the effect of qigong on sleep disturbance in patients with cancer were inconsistent. Wayne et al.[104] found a beneficial effect of qigong on sleep disturbance in three RCTs, compared with an active control intervention, and a non-statistically significant effect in four RCTs, compared with UC or WL control interventions. Cheung et al.[20] found that qigong significantly improved sleep quality in patients with cancer at post-intervention, with high heterogeneity ($I^2 > 90\%$). Another meta-analysis in patients with breast cancer revealed no taichi-induced improvement in sleep quality, compared with UC in two RCTs.[105] In this study, five of the eight included meta-analyses were conducted in patients undergoing active cancer treatment (chemotherapy or radiotherapy), and thus qigong intervention might not have demonstrated a protective effect on patients' sleep health due to the treatment-related burden. Future research should identify the effects of qigong in patients with cancer at different treatment stages.

To our knowledge, no previous meta-analysis has evaluated the effects of relaxation and hypnosis on sleep among patients with cancer. Although we found immediate effects of these two therapies on subjective sleep disturbance, compared with UC or WL control, the heterogeneity was high ($I^2 > 70\%$). Relaxation is a skill aimed at eliciting a state of relative freedom from mental and physical tension, including progressive muscle relaxation, abdominal breathing, focused breathing, and jaw relaxation.[106] Samuel et al.[107] conducted a systematic review and reported no evidence regarding the effects of relaxation on sleep health among patients with cancer, which supports our findings. Hypnosis is a promising treatment option for insomnia and disorders of arousal.[108] Reviews have demonstrated the beneficial effects of hypnosis on sleep health among adults and menopausal women.[109,110] Because there was only one study on imagery intervention in this systematic review, a meta-analysis was not conducted. Future RCTs should be conducted to identify the sleep-related effects of relaxation, hypnosis, and imagery in patients with cancer.

4.3. Implication for practice and research

Extant evidence from the included RCTs in this meta-analysis suggests that mindfulness, yoga, relaxation, and hypnosis can relieve sleep disturbance at post-intervention. Practitioners should consider MBTs as integrative approaches for managing sleep disturbances in patients with cancer. Mindfulness may be recommended for patients with cancer, given its sustainable effect on sleep disturbance severity reduction and its immediate effect on SOL reduction and TST augmentation. Yoga may be another recommended alternative therapy, as it may reduce sleep disturbance and WASO at post-intervention, although the effect is not sustainable. MBTs could be administered in various formats, including face-to-face interventions, internet formats, and audio-recorded formats; further, MBTs can be administered to an individual or a group. A flexible format would be suitable for patients with cancer at different treatment stages, such as during the perioperative period, chemotherapy or radiotherapy, and treatment completion. Moreover, MBTs can be delivered by social workers and nurses at a low cost, which may be advantageous for future cost-effective research.

Additional RCTs with rigorous study designs are needed to verify our recommendations given the various unclear methodological weaknesses in this review. Additional RCTs related qigong, relaxation, and hyponosis are needed to verify our findings. Future studies should collect and report subjective and objective sleep outcomes; collect 6-month or longer follow-up outcomes; report the reasons for missing data and the approaches used to address missing data.

4.4. Limitations

This study has limitations. First, as there is no categorization of MBTs, the excluded therapies in this systematic review and meta-analysis could have had an impact on the reported results. Second, only English articles were included in this systematic review. The studies excluded from our meta-analysis might have produced different results from what is herein reported. Third, regarding objective sleep outcomes, the subgroup meta-analysis was conducted among two or three studies, which might have led to result inconsistencies. Finally, the funnel plots indicated some publication bias for MBTs.

5. Conclusions

Among MBTs, mindfulness, yoga, relaxation, and hypnosis were effective in reducing the severity of subjective sleep disturbance among patients with cancer at post-intervention, and the effect of mindfulness lasted at least 6 months. MBTs were not superior to active control interventions in improving sleep. However, there were high heterogeneity, many pilot studies, and insufficient data in some sub-analyses in this review, further RCTs with rigorous study designs are needed to verify our recommendations.

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CRediT authorship contribution statement

Jing Han: Conceptualization, Resources, Writing – original draft. **Hui-Lin Cheng:** Methodology, Validation, Writing – review & editing. **Liu-Na Bi:** Resources, Validation. **Alex Molasitis:** Conceptualization, Supervision, Writing – review & editing.

Declaration of Competing Interest

None declared.

Appendix A. Search strategy

Search number	Search terms	Search results
Medline		
S1	TX neoplasms* OR TX cancer* OR TX tumor* OR TX carcinoma* OR TX adenocarcinoma* OR TX leukemi* OR TX leukaemia* OR TX lymphoma* OR TX malignan* OR TX melanoma* OR TX sarcoma*	5947,940
S2	TX mind body therap* OR TX mind body intervention* OR TX mindfulness based* OR TX mindfulness based stress reduction OR TX mbsr* OR TX mindfulness based cognitive therapy OR TX mbct* OR TX meditation* OR TX mindfulness* OR TX taichi OR TX tai chi* OR TX tai ji*	26,969
S3	TX qigong OR TX chi kung OR TX qi gong OR TX baiduanjin* OR TX yoga OR TX hypnosis OR TX imagery OR TX relaxation	195,961
S4	S2 OR S3	217,085
S5	TX insomnia OR TX dyssomnia OR TX sleep disorder* OR TX sleep disturbance OR TX insomni* OR TX sleep*	337,118
S6	S1 AND S4 AND S5	1623
S7	Limiters - Human; Randomized Controlled Trials	275
Embase		
#1	neoplas* OR cancer* OR carcinoma* OR tumour* OR adenocarcinoma* OR leukemi* OR leukaemia* OR lymphoma* OR malignan* OR melanoma* OR sarcoma*	6620,582
#2	(mind body therap*) OR (mind body intervention*) OR (mindfulness based*) OR (mindfulness based stress reduction) OR mbsr* OR (mindfulness based cognitive therapy) OR mbct*	20,136
#3	meditation* OR mindfulness* OR taichi OR (tai chi*) OR (tai ji*) OR qigong OR (chi kung) OR (qi gong) OR (baiduanjin*) OR yoga OR hypnosis OR imagery OR relaxation	314,572
#4	#2 OR #3	321,710
#5	insomnia OR dyssomnia OR (sleep disorder*) OR (sleep disturbance) OR insomni* OR sleep*	507,825
#6	#1 AND #4 AND #5	724
Search number	Search terms	Search results
CINAHL		
S1	TX neoplas* OR TX cancer* OR TX carcinoma* OR TX tumour* OR TX adenocarcinoma* OR TX leukemi* OR TX leukaemia* OR TX lymphoma* OR TX malignan* OR TX melanoma* OR TX sarcoma*	1186,237
S2	TX mind body therap* OR TX mind body intervention* OR TX mindfulness based* OR TX mindfulness based stress reduction OR TX mbsr* OR TX mindfulness based cognitive therapy OR TX mbct* OR TX meditation* OR TX mindfulness*	39,149
S3	TX taichi OR TX tai chi* OR TX tai ji* OR TX qigong OR TX chi kung OR TX qi gong OR TX baiduanjin* OR TX yoga OR TX hypnosis OR TX imagery OR TX relaxation	105,473
S4	S2 OR S3	129,297
S5	TX insomnia OR TX dyssomnia OR TX sleep disorder* OR TX sleep disturbance OR TX insomni* OR TX sleep*	231,870
S6	S1 AND S4 AND S5	9283
S7	Limiters - Human; Randomized Controlled Trials	455
Cochrane center of trails database		
#1	neoplas* OR cancer* OR carcinoma* OR tumour* OR adenocarcinoma* OR leukemi* OR leukaemia* OR lymphoma* OR malignan* OR melanoma* OR sarcoma* in All Text - (Word variations have been searched)	252,437
#2	(mind body therap*) OR (mind body intervention*) OR (mindfulness based*) OR (mindfulness based stress reduction) OR mbsr* OR (mindfulness based cognitive therapy) OR mbct* in All Text - (Word variations have been searched)	6901
#3	meditation* OR mindfulness* OR taichi OR (tai chi*) OR (tai ji*) OR qigong OR (chi kung) OR (qi gong) OR (baiduanjin*) OR yoga OR hypnosis OR imagery OR relaxation in All Text - (Word variations have been searched)	34,713
#4	#2 OR #3	32,410
Search number	Search terms	Search results
#5	insomnia OR dyssomnia OR (sleep disorder*) OR (sleep disturbance) OR insomni* OR sleep* in All Text - (Word variations have been searched)	54,521
#6	#1 AND #4 AND #5	574
Scopus		
	(TITLE-ABS-KEY (neoplas* OR cancer* OR carcinoma* OR tumour* OR adenocarcinoma* OR leukemi* OR leukaemia* OR lymphoma* OR malignan* OR melanoma* OR sarcoma*) AND TITLE-ABS-KEY (“mind body therap*” OR “mind body intervention*” OR “mindfulness based*” OR “mindfulness based stress reduction” OR mbsr* OR “mindfulness based cognitive therapy” OR mbct* OR meditation* OR mindfulness* OR taichi OR “tai chi*” OR “tai ji*” OR qigong OR “chi kung” OR “qi gong” OR baiduanjin* OR yoga OR hypnosis OR imagery OR relaxation) AND TITLE-ABS-KEY (insomnia OR dyssomnia OR “sleep disorder*” OR “sleep disturbance” OR insomni* OR sleep*) AND TITLE-ABS-KEY (random* OR placebo OR rct* OR control* OR comparison AND stud* OR comparison AND group))	761

(*continued on next page*)

(*continued*)

Search number	Search terms	Search results
Pubmed		
	((((neoplas* or cancer* or carcinoma* or tumour* or adenocarcinoma* or leukemi* or leukaemia* or lymphoma* or malignan* or melanoma* or sarcoma*)) AND (mind body therap* or mind body intervention* or mindfulness based* or mindfulness based stress reduction or mbsr* or mindfulness based cognitive therapy or mbct* or meditation* or mindfulness* or taichi or tai chi* or tai ji* or qigong or chi kung or qi gong or baiduanjin* or yoga or hypnosis or imagery or relaxation)) AND (insomnia or dyssomnia or sleep disorder* or sleep disturbance or insomni* or sleep*)) AND (random* or placebo or rct* or control* or comparison stud* or comparison group)	188
PsycINFO		
S1	neoplas* OR cancer* OR carcinoma* OR tumour* OR adenocarcinoma* OR leukemi* OR leukaemia* OR lymphoma* OR malignan* OR melanoma* OR sarcoma* (Limiters: clinical trail)	2308
Search number	Search terms	Search results
S2	(mind body therap*) OR (mind body intervention*) OR (mindfulness based*) OR (mindfulness based stress reduction) OR mbsr* OR (mindfulness based cognitive therapy) OR mbct* (Limiters: clinical trail)	802
S3	meditation* OR mindfulness* OR taichi OR (tai chi*) OR (tai ji*) OR qigong OR (chi kung) OR (qi gong) OR (baiduanjin*) OR yoga OR hypnosis OR imagery OR relaxation (Limiters: clinical trail)	1713
S4	insomnia OR dyssomnia OR (sleep disorder*) OR (sleep disturbance) OR insomni* OR sleep* (Limiters: clinical trail)	2832
S5	S1 AND (S2 OR S3) AND S4	34

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ctim.2023.102954.

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