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CLINICAL REVIEW

Walking is more effective than yoga at reducing sleep disturbance in cancer patients: A systematic review and meta-analysis of randomized controlled trials

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SUMMARY

This review aimed to determine whether walking is more effective than yoga at improving sleep disturbance in cancer patients. A systematic search of randomized controlled trials was performed in the PubMed, EMBASE, CINAHL, Cochrane Library, CNKI, Airiti Library, and other health-related databases. Twenty-five studies were identified with a total of 1918 participants. The Pittsburgh sleep quality index was the most commonly used outcome measurement tool, and moderate-intensity walking was the most frequently used intervention. The majority of the included subjects were breast cancer patients. Overall, walking significantly improved sleep disturbance compared to yoga ($p = 0.01$). Statistically significant moderators included adherence rate for walking ($p < 0.001$) and allocation concealment and outcome measurement tool for yoga ($p = 0.04$; $p = 0.03$). We concluded that walking is more effective than yoga in improving sleep disturbance in cancer patients. Thus, moderate-intensity walking is recommended for cancer patients with sleep disturbance.

Introduction

Sleep disturbance is detrimental to cancer patients and associated with increased psychological distress, impaired physical function, and high mortality rates [1–3]. This burdensome cluster of symptoms, including insomnia, early awakening, and excessive daytime sleepiness, is reported in 30–87% of cancer patients [4]. While sleep disturbance can occur after a cancer diagnosis or during anticancer treatments, many cancer survivors continue to have insomnia for years [4–6]. Sleep medication is the most commonly prescribed therapy for sleep disturbed cancer patients, but the safety and effectiveness of pharmacologic treatments have not been established in this population. Furthermore, evidence suggests that the use of non-pharmacological treatments might be more beneficial for relieving sleep disturbance [7,8].

Exercise is commonly recommended to treat sleep disturbance. Several systematic reviews indicated that regular exercise improves cancer patients' sleep quality and quality of life [9–11]. However, these reviews are limited to the Chinese or English literature, but not both. Additionally, these reviews included an overly wide spectrum of nonpharmacological interventions ranging from Tai chi, Qigong, and behavioral therapy to music therapy. The heterogeneity of clinical evidence and recommendations made it impractical for clinicians to identify the appropriate exercise for their cancer patients. Furthermore, previous studies failed to provide any specific recommendations for exercise dosage and format, indispensable components in prescribing physical exercises. These limitations weakened the impact of the current systematic review.

Glossary of terms: RCT, randomized controlled trial; SMD, standardized mean differences; CI, confidence interval; PSQI, Pittsburgh sleep quality index.

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Low-level exercises are safe for most cardiac patients, but the potential for an adverse cardiopulmonary event during exercise might be higher in cancer patients due to toxic cancer treatments [12,13]. Previous studies have shown that walking and yoga are the most common physical exercises used to treat sleep disturbance, and both are safe and feasible for cancer patients [14–16].

With approximately 40–80% of the global population living a sedentary lifestyle, walking has been recommended as a minimal effort activity; it can reduce the risk of all-cause mortality, postpone functional decline, and extend one's life expectancy [17,18]. Studies have revealed that mild-to moderate-intensity walking improves both sleep quality and quality of life of cancer patients. The walking groups also had less fatigue, better mental health, and higher exercise capacity than the usual care groups [19–21]. Physical exercise (e.g., walking) influences sleep through several mechanisms [22]. Adequate walking exercise can readily raise body temperature, and the decline in core body temperature after exercise increases the likelihood of sleep onset [22]. Morning exercise reduces melatonin production at the time of the exercise stimulus, which ameliorates daytime sleepiness and regulates circadian rhythms [23]. Sleep disturbance, such as short sleep duration and insomnia, have also been related to increased inflammation, and regular exercise can reduce low-grade inflammation and improve sleep quality [4,24]. Walking exercise also regulates sleep through other complex mechanisms, such as cardiac, endocrine, and metabolic functions.

Yoga has grown in popularity as a regular physical activity and a therapeutic intervention to promote health and reduce stress [25,26]. Recently, yoga has shown promising results in improving sleep disturbance in cancer patients. The largest clinical trial of yoga in cancer patients, the Yoga for Cancer Survivors (YOCAS®) program, revealed that yoga can improve sleep, fatigue, and quality of life [27]. Cohen and colleagues [28] reported that patients with lymphoma undergoing chemotherapy demonstrated significant improvements in sleep-related outcomes following the yoga intervention program. Yoga practice in the modern context generally includes posture exercise, meditation, and breathing control, and it might regulate the immune system, circadian clock, and cardiac function in the same way as other physical exercises to alleviate sleep disturbance [29,30]. Yoga is also characterized as a mindful mode of physical activity. Mindfulness, as an important component of yoga, improves sleep disturbance by increasing melatonin levels, reducing hyperarousal, and addressing stress-related cardiac and respiratory abnormalities [7].

To the best of our knowledge, no studies have compared the effectiveness of walking and yoga at improving sleep disturbance in cancer patients. Hence, this systematic review and meta-analysis addresses these gaps in the literature by comparing existing randomized controlled trials (RCTs) on these exercises' effectiveness at improving sleep disturbance in cancer patients. We hypothesized that walking is more effective than yoga at improving sleep disturbance because walking is more standardized, whereas yoga is less standardized. This review aimed to provide healthcare professionals with evidence-based guidance on exercise prescriptions for managing sleep disturbance in cancer patients.

Method

Literature search

The Preferred Reporting Items for Systematic reviews and Meta-Analyses was adapted to guide the current study [31]. To identify relevant publications, a trained librarian conducted a comprehensive computer-based search of articles from January 1997 to January 2018 in PubMed, EMBASE, CINAHL, Cochrane Library, Airiti Library, National Digital Library of Theses and Dissertations in Taiwan, and the China Knowledge Resource Integrated (CNKI) Database (see Fig. S1). The references of the retrieved articles were manually screened for relevant studies. The following keyword combinations were used in the searches: ((“neoplasms” [MeSH Terms] OR “neoplasms” [All Fields] OR “cancer” [All Fields]) AND (“walking” [MeSH Terms] OR “walking” [All Fields])) AND (“sleep” [MeSH Terms] OR “sleep” [All Fields]), ((“neoplasms” [MeSH Terms] OR “neoplasms” [All Fields] OR “cancer” [All Fields]) AND (“sleep” [MeSH Terms] OR “sleep” [All Fields])) AND (“yoga” [MeSH Terms] OR “yoga” [All Fields]).

Inclusion criteria

Inclusion criteria used to identify eligible published RCT studies of walking or yoga were: 1) studied sample: adult patient (age $\geq$ 20 y) with any cancer diagnosis, including survivors who completed cancer treatments; 2) intervention characteristic: at least one intervention group performing walking or yoga; 3) control group: inclusion of a group that did not perform walking or yoga or did not perform walking or yoga until after the RCT (wait-list); 4) study outcome: change in sleep disturbance after the intervention; 5) RCT design; and 6) only full-text articles written in Chinese or English. Two reviewers (MT, HC) independently evaluated the eligibility of each article according to the inclusion criteria. Studies were excluded if they did not match the inclusion criteria (e.g., no available Chinese or English full-text, synthesis articles, patients with no cancer diagnosis, study design other than yoga or walking). For any discrepancies, a third independent reviewer intervened until a consensus was reached.

Data extraction and assessment of study quality

Data extraction was performed by two independent reviewers (MT, HC) using a predesigned data extraction form. The following data were extracted from each study: design, studied sample, intervention characteristics (including exercise type, intensity, and frequency and study duration), control group, sample size, study result, adverse effect, and adherence rate. The two completed forms were compared for any inconsistencies to ensure accuracy of the data extraction. Study quality using assessment tools for the risk of bias from the Cochrane Handbook for Systematic Reviews of Intervention version 5.1.0 [32] was also recorded. Domains, such as random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, and selective reporting, were rated as “high risk,” “unclear,” or “low risk” by two independent reviewers.

Statistical analysis

The random effects model was used to calculate the pooled effect size of the included studies. The extracted continuous data from different scales were converted to standardized mean differences (SMD) with 95% confidence intervals (CIs), the “effect size” known in social science [32]. An effect size of <0.2 was considered a small effect, 0.5 was a moderate effect, and 0.8 was a large effect [33]. The SMD with 95% CI was used to present the difference in sleep changes in the walking versus yoga group. The I^2 test was used to determine the degree of heterogeneity, with $I^2 \geq 50\%$ indicating substantial interstudy heterogeneity [32]. The meta-analysis results were expressed as the pooled effect, with corresponding 95% CI and p value. A subgroup analysis comparing the effects of walking and yoga on cancer-related sleep disturbance was performed according to our hypothesis that walking may be more effective than yoga at improving sleep disturbance among cancer

survivors. Subgroup and meta-regression analyses were further performed to identify possible reasons for interstudy heterogeneity. The subgroup analysis adapted prespecified covariates, including cancer type, intervention type, participant age, participant sex, intervention duration, cancer treatment at enrollment, and study quality. The robustness of the study findings was assessed using sensitivity analysis. Potential publication bias was evaluated using the Egger's intercept test, with p values < 0.05 signifying significant bias [34].

Results

Search results and study description

Of 998 identified studies, 25 met the inclusion criteria (Fig. S1). Among them, 24 were published in English and one was published in Chinese [35]. Table 1 presents the sample characteristics of each study. The sample size of the included studies ranged from 20 to 410, involving 1918 randomized cancer patients. The mean age of the included participants was 55.1 (±8.8) y; 86% were female. The most commonly used outcome measurement tool was the Pittsburgh sleep quality index (PSQI; 17/25). Study intervention characteristics are presented in Table S1. Thirteen studies used yoga as the intervention for sleep disturbance (1227 participants); 12 studies used walking as the intervention (691 participants). The mean intervention duration was 8.4 wk and the mean adherence rate was 83.1%. Most studies (n = 17) did not report on adverse effects following the interventions; six studies reported a total of 18 (1.88%) adverse cases ranging from tachycardia to negative mood [15,19–21,27,36], while two studies reported that no adverse effects occurred.

Among the studies that used yoga as the intervention, all but one did not disclose the exercise intensity [27]. The sample sizes were 28–410. Approximately 77% of the participants had breast cancer, mostly stage I–III. All but two studies [37,38] offered yoga classes in group settings, and all classes were led by well-trained instructors. Most yoga intervention sessions were implemented at least once a week for 4–12 wk. Of 13 studies that used yoga as the intervention, only three reported the duration of each exercise session (range, 75–120 min).

Among the studies that used walking as the intervention, most were moderate in intensity, while the remaining two were low to moderate in intensity [21,39]. The sample sizes were 20–126. Half of the participants had breast cancer, mostly stage I–III. The frequency of the walking sessions was two to seven times a week for 4 wk to 1 y. Home-based walking was the most common exercise type (66.7%); other studies combined home-based walking and resistance training.

Assessment of risk of bias

As shown in Table S2, some included articles were rated at a high or unclear risk of bias in terms of the domains of incomplete outcome data (n = 13); blinding of the participants, personnel, and outcome assessors (n = 8); random sequence generation (n = 4); and allocation concealment (n = 2). However, we found no included studies with potential bias regarding the domain of selective reporting.

Effect of walking and yoga on sleep disturbance

The random effects model was applied to analyze the 25 studies (Fig. S2, Table 2). The combined data showed a significant improvement in sleep disturbance (SMD = −0.42, 95% CI, −0.57 to −0.27). However, significant heterogeneity existed among the studies (Q = 52.30, p < 0.001, I^2 = 54.11%). The subgroup analysis revealed that exercise type was the main cause of the marked heterogeneity; studies that employed walking as the intervention showed greater improvement in sleep disturbance than studies that used yoga as the intervention (SMD = −0.62 vs. −0.26, p = 0.01). Substantial heterogeneity was found in the walking and yoga studies (Q = 20.13, p = 0.04 vs. Q = 18.99, p = 0.09). Therefore, moderator and meta-regression analyses were conducted to further explore the determinants of the heterogeneity.

Moderator, meta-regression, and sensitivity analyses

For the heterogeneity in walking studies, adherence rate was the only moderator to explain the heterogeneity (p < 0.001; Table S3). In the yoga studies, moderator analyses revealed that studies that used other instruments as outcome measurement tools showed a greater reduction in sleep disturbance than did studies that used the PSQI (SMD = −0.55 vs. −0.16, p = 0.03; Table S4). Studies rated at low risk of bias in allocation concealment (low vs. high/unclear risk; Hedges' g = −0.43 vs. −0.11) showed a larger improvement in sleep disturbance than studies with a high or unclear risk of bias (SMD = −0.43 vs. −0.11, p = 0.04). Regression analysis of study publication dates revealed a positive correlation with study effect size (p < 0.001; Table S5), indicating that more recent studies were more likely to have significant results. Sensitivity analysis of female sex and mixed sex for treating sleep disturbance indicated no statistically significance in different sex groups (SMD = −0.37 vs. −0.52, p = 0.17). No significant subgroup differences were identified for the diagnosis types (breast cancer vs. non-breast cancer), outcome measures (PSQI vs. other instruments), or cancer treatment at enrollment (during treatments only vs. others).

To ensure the robustness of the findings, sensitivity analyses were performed by excluding the study with the largest effect size. The result remained statistically significant (SMD = −0.38, 95% CI, −0.52 to −0.24).

Publication bias

Potential publication bias was analyzed using Egger's regression and Begg's tests; both were negative (p = 0.09 and p = 0.25, respectively). Moreover, there was no publication bias in the walking or yoga subgroups using Egger's test (p = 0.56 vs. p = 0.48) or Begg's test (p = 0.84 vs. p = 0.43).

Discussion

Main findings

With respect to the meta-analysis of the effects of general exercise at improving sleep disturbance in cancer patients, our results yielded statistically significant differences, revealing that regular exercise could ameliorate the burden of sleep disturbance in cancer patients. This outcome supported those of previous meta-analysis studies conducted by Papadopolos et al. [10] and Chiu et al. [9]. Previous studies have shown that walking is an effective sleep disturbance intervention for different demographic groups, including healthy workers, general elderly individuals, facility-dwelling adults, and patients with cardiovascular problems [40–43]. This study provides evidence that this accessible and feasible physical activity is also an effective sleep disturbance intervention for cancer patients. The effect of walking for reducing sleep disturbance in cancer patients is superior to yoga.

Table 1
Sample characteristics of walking and yoga studies in alphabetical order by first author.

Author, reference number	Country	Age: Exercise/Control (average age)	Gender: Female/ Male	Cancer Type	Cancer stage	Sample size Exercise/control	Cancer treatment at enrollment	Outcome measurement
Walking								
Chen HM et al. 2016 [15]	Taiwan	64.6 ± 11.5/62.5 ± 9.6 (63.6 ± 10.6)	62/49	Lung cancer	Stage I-IV	56/55 (111)	During/after	PSQI[a]
Cheville AL et al. 2013 [48]	United States	63.8 ± 12.5/65.5 ± 8.9 (64.7 ± 10.7)	31/35	Lung cancer; colorectal cancer	Stage IV	33/33 (66)	During/after	Symptom numeric rating scales
Donnelly CM et al. 2011 [44]	United Kingdom	53.5 ± 8.7/52.1 ± 11.8 (52.8 ± 10.3)	33/0	Gynecological cancer (Ovarian/endometrial/ uterine/cervical)	Stage I-III	16/17 (33)	Before/during/after	PSQI
Mock V et al. 1997 [51]	United States	48.1 ± 5.4/50.3 ± 8.5 (49.2 ± 7)	46/0	Breast cancer	Stage I-И	22/24 (46)	During only	Symptom assessment scales
Naraphong W et al. 2015 [39]	United States	46.4 ± 9.4/47.2 ± 6.9 (46.8 ± 8.2)	23/0	Breast cancer	Stage I- III	11/12 (23)	During only	General sleep disturbance scale
Payne JK et al. 2008 [19]	United States	64.7 ± 6.3	20/0	Breast cancer	Not reported	10/10 (20)	During only	PSQI
Rogers LQ et al. 2009 [53]	United States	53 ± 9	41/0	Breast cancer	Stage I- IIIA	21/20 (41)	During only	PSQI
Rogers LQ et al. 2015 [16]	United States	56.2 ± 7.7	44/0	Breast cancer	Stage I- И	22/22 (44)	During/after	PSQI
Sprod LK et al. 2010 [45]	United States	56.6 ± 13.7/63.3 ± 9.4 (60.0 ± 11.6)	27/11	Breast cancer; prostate cancer	Not reported	19/19 (38)	During only	PSQI
Tang MF et al. 2010 [20]	Taiwan	47.4 ± 10.1/56.4 ± 12.4 (51.9 ± 11.3)	54/17	All cancer diagnosis	Stage I-IV	36/35 (71)	During/after	PSQI
Wang YJ et al. 2011 [21]	Taiwan	48.4 ± 10.2/52.3 ± 8.9 (50.4 ± 9.6)	72/0	Breast cancer	Stage I-И	35/37 (72)	During/after	PSQI
Wenzel JA et al. 2013 [55]	United States	59.8 ± 10.8/60.6 ± 10.8 (60.2 ± 10.8)	49/77	Solid tumor cancer (breast/prostate/colon cancer)	Stage I-III	68/58 (126)	During only	PSQI
Yoga								
Andysz A et al. 2014 [46]	Poland	54.8 ± 7.4/58.6 ± 10.8 (56.7 ± 9.1)	28/0	Breast cancer	Stage I	12/16 (28)	During only	Global health status and quality of life scale
Carson JW et al. 2009 [36]	United States	53.9 ± 9.0/54.9 ± 6.2 (54.4 ± 7.6)	37/0	Breast cancer	Stage IA-ИB	17/20 (37)	Before/during/after	0-9 Scales
Chandwani KD et al. 2010 [37]	United States	51.4 ± 7.9/54.0 ± 9.9 (52.7 ± 8.9)	61/0	Breast cancer	Stage 0-III	30/31 (61)	During only	PSQI
Chandwani KD et al. 2014 [47]	United States	52.4 ± 1.4/52.1 ± 1.3 (52.3 ± 1.4)	107/0	Breast cancer	Stage 0-III	53/54 (107)	During only	PSQI
Chaoul A et al. 2018 [14]	United States	49.5 ± 9.8/49 ± 10.1 (49.3 ± 10)	159/0	Breast cancer	Stage I-III	74/85 (159)	During only	PSQI
Cohen L et al. 2004 [28]	United States	51/51 (51)	12/27	Lymphoma	Stage I-IV	20/19 (39)	During/after	PSQI
Cramer H et al. 2016 [49]	Germany	68.7 ± 9.1/67.8 ± 10.4 (68.3 ± 9.8)	21/33	Colorectal cancer	Stage I-III	27/27 (54)	Before/during/after	PSQI
Danhauer SC et al. 2009 [50]	United States	54.3 ± 9.6/57.2 ± 10.2 (55.8 ± 9.9)	44/0	Breast cancer	Stage I-IV	22/22 (44)	Before/during/after	PSQI
Mustian KM et al. 2013 [27]	United States	54.3 ± 11.154.0 ± 9.6 (54.2 ± 10.4)	393/17	All cancer diagnosis	Stage I-IV	206/204 (410)	During/after	PSQI
Ratcliff CG et al. 2016 [52]	United States	52.4 ± 9.8/52.1 ± 9.8 (52.3 ± 9.8)	107/0	Breast cancer	Stage 0-III	53/54 (107)	During only	PSQI
Taylor TR et al. 2018 [54]	United States	54.9 ± 8.8/52.6 ± 8.2 (53.8 ± 8.5)	33/0	Breast cancer	Not reported	18/15 (33)	During/after	Insomnia severity index
Vadiraja SH et al. 2009 [38]	India	Not reported	88/0	Breast cancer	Stage I-III	44/44 (88)	During only	EORTC QLQ-C30[b]
Wang CQ et al. 2010 [35]	China	47.5 ± 5.3/48.1 ± 3.6 (47.8 ± 4.5)	60/0	Breast cancer	Not reported	30/30 (60)	Before/during/after	Self-rating scale of sleep

[a] PSQI: Pittsburgh sleep quality index.
[b] EORTC QLQ-C30: The European Organization for Research and Treatment of Cancer quality of life questionnaire.

Table 2
Mean effect sizes, moderator analyses, and quality analyses of included studies.

Parameter	k	Effect Size (Hedges' g)	95% CI	p
Categorical Moderators				
Random sequence generation				
Low risk	20	−0.43	−0.59, −0.27	0.97
High/unclear risk	5	−0.42	−0.84, 0.00	
Allocation concealment				
Low risk	11	−0.44	−0.61, −0.27	0.84
High/unclear risk	14	−0.41	−0.64, −0.18	
Cancer type				
Breast cancer	16	−0.36	−0.57, −0.17	0.33
Others	9	−0.52	−0.77, −0.28	
Type of intervention				
Walking exercise	12	−0.62	−0.84, −0.40	0.01*
Yoga exercise	13	−0.26	−0.42, −0.10	
Outcome measurement				
PSQI	17	−0.37	−0.54, −0.19	0.09
Others	8	−0.61	−0.83, −0.39	
Cancer treatment at enrollment				
During only	12	−0.27	−0.48, −0.07	0.05
Before/during/after	13	−0.55	−0.75, −0.36	
Parameter	K	β	95% CI	P
Continuous Moderators				
Age	24	−0.01	−0.03, 0.01	0.42
Duration per session	24	−0.01	−0.04, 0.02	0.46
Adherence rate	24	0.00	−0.01, 0.01	0.64
Percentage of Female participants	25	0.00	−0.00, 0.01	0.17
Frequency per session	24	0.03	−0.02, 0.08	0.22
Sample size	25	0.00	−0.00, 0.00	0.11
Publication date	25	0.04	0.02, 0.07	0.00*

Plausible explanations for the differential intervention effects of walking and yoga

Standardization of exercise intensity

A possible reason that explains the superiority of walking is the ease in the measured intensity level since it involves linear and repetitive motions. A total of 12 included studies that used walking as the intervention reported the exercise intensity; half of them incorporated the percentage of target heart rate or rating of perceived exertion to establish the intensity level [15,20,21,39,44,45]. Easy-to-use instruments, such as the rating of perceived exertion, can help participants control and maintain the appropriate exercise intensity, which is especially useful for patients practicing at home. With respect to yoga trials, only one study [27] specified the exercise intensity. Yoga improves sleep through a unique mechanism of mindfulness. However, its intensity is often inconstant due to changes in position. Physiological changes promoting better sleep (e.g., changes in body temperature, melatonin release, and reduced inflammation) might not be triggered with insufficient intensity. Mindfulness without adequate exercise intensity might be less effective than walking with desired intensity for improving sleep disturbance.

Composition of unsupervised home-based sessions and intervention duration

Another explanation for the inferiority of yoga could be the fact that practicing yoga at home without an instructor might be challenging. The adherence rates of the walking and yoga groups were similar (83.1% vs. 81.1%, respectively). More than half of the walking trials required at least three walking sessions per week, whereas only five of the yoga trials offered in-person classes more than once a week, and participants were often encouraged to practice at home. In Chandwani et al.'s [37] yoga study, the intervention group attended two yoga classes per week and was encouraged to practice daily at home, following a recorded lesson on days with no classes. The adherence rate for in-person sessions was 90%, and 96% of the participants reported home practice at least two times per week during the 6-wk intervention. However, the frequency of home practice that was performed at least twice weekly had decreased to 50% at the 3-mo follow-up. Most of the included yoga studies used strategies of recorded lessons, written instructions, and daily logging to encourage home-based exercise engagement. However, practicing yoga daily without supervision and professional feedback can be challenging for beginners, and the insufficient exercise intensity may have reduced its effectiveness. The mean intervention duration for the included walking trials was 8.4 wk, which was longer than that of the yoga trials (7.75 wk); the longer program duration might also contribute to the more evident effectiveness of walking at improving sleep disturbance.

Factors associated with intervention effect

We found that the study publication date exhibited a positive correlation with the intervention effect. This could be explained due to the fact that the recently conducted studies might have more rigorous study designs; therefore, the interventions yielded more desirable outcomes. Additionally, we found, for the yoga subgroup, studies that used PSQI as the measurement tool demonstrated less improvement compared to studies using other tools (such as the insomnia severity index, The European Organization for Research and Treatment of Cancer quality of life questionnaire [EORTC QLQ-C30], and the self-rating scale of sleep). The PSQI had a longer symptom recall time of one month compared to one week for the EORTC QLQ-C30 and current for the insomnia severity index, which might affect the recall reliability of the PSQI. A recent systematic review and meta-analysis on exercise and sleep quality indicated that exercise might improve PSQI more significantly in patients with insomnia than in those with sleep complaints [47]. The PSQI, a subjective tool, might not be able to reflect the subtler sleep disturbance improvements in cancer patients. In future studies,

objective sleep pattern measuring tools, such as actigraphy or video recording, should be incorporated to more accurately evaluate the effect of exercise on sleep disturbance [48].

Recommendations for practice

In our review, the exercise frequency was observed to be more than three times a week in around 80% of the studies, and more than half of the interventions lasted longer than 8 wk. A previous meta-analysis demonstrated that moderate-intensity exercise, rather than mild or vigorous exercise, is beneficial and should be recommended to cancer patients for sleep improvement [9]. Our findings augment this recommendation with additional suggestions regarding the mode of exercise: First, an 8-wk program of three weekly sessions of moderate-intensity walking can be advised for patients with different cancer diagnoses and at all treatment stages. Second, walking can be prescribed as an independent intervention and used in combination with other forms of exercise. Third, exercise can have adverse effects in patients with cardiovascular and respiratory impairments. Therefore, these patients should be carefully evaluated using lung function tests and exercise electrocardiography prior to any exercise intervention. Furthermore, the public should be educated about the sleep-related benefits of moderate-intensity walking, and exercise should be promoted in hospitals and the community. In addition, overtraining can cause distress to the central nervous system, which may lead to sleep pattern changes and sleep disturbance [49]. Therefore, the public should also be educated about the importance of a properly planned periodization exercise regimen with appropriate duration and intensity.

Regarding the choice of walking vs yoga, despite the inferiority of yoga's effect, yoga has a positive effect on improving sleep disturbance, and it has been well tolerated by a wide range of cancer patients, even in individuals with limited mobility [50]. Therefore, if the patient prefers yoga over walking, yoga exercise should be encouraged. As professional coaching required in yoga might be costly to some cancer patients, a more cost-effective mode of yoga training delivery should be further investigated by the policy makers to enhance its application to a wider patient population. Notably, walking and yoga are both generally safe for most cancer patients; yet, six of the included studies reported a total of 18 adverse events related to the interventions. The reported adverse events included negative mood, feeling unwell, tachycardia, worsening health, and anemia. Although adverse events occurred in only 0.2−10% of the participants, close monitoring and supervised exercise sessions are required for high-risk patients, especially those with cardiac or pulmonary comorbidities.

Recommendations for further research

The data extraction and analyses were challenging due to the significant heterogeneity among the studies. Additionally, some selected studies did not explain the randomized process explicitly and thoroughly, causing suboptimal study quality. The effectiveness of walking and yoga at improving sleep disturbance in cancer patients has been widely studied. However, to the best of our knowledge, no study has compared the effectiveness of the two interventions domestically and internationally. Future research should focus on the effectiveness of exercise interventions in the clinical setting to provide more evidence-based guidance and to better serve more patients. Due to the fact that the vast majority of current studies included individuals with breast cancer, future studies should include patients with other cancer diagnoses to increase our understanding of the effectiveness of the exercise intervention on different patient populations. Additionally, well-designed yoga trials are required to elucidate its treatment effects on sleep disturbance. Future studies should also include literature in more languages if possible. Finally, RCTs on walking and yoga in cancer patients with sleep disturbance should be designed and conducted to accurately evaluate the effectiveness of the two interventions.

Limitations

To ensure the scientific rigor of our study, we included only RCTs in this systematic review and meta-analysis. Nevertheless, this review had some limitations that require consideration. First, its heterogeneity is high due to the variabilities in intervention duration and frequency. Significant heterogeneity can potentially restrict the reliability of the meta-analysis and applicability of the conclusion. Second, our review was expanded to include the English and Chinese literature, but we might have missed important findings in other languages. Third, two studies had low adherence rates, 50% and 59%. Finally, about 72% of the participants had breast cancer, and the findings of our study are not necessarily generalizable to men or to women with other types of cancer.

Conclusion

This systematic review and meta-analysis found that walking is a more effective intervention than yoga for improving sleep in cancer patients. Moderate-intensity walking has positive effects in cancer patients with sleep disturbance. With its high adherence rate and simple intensity estimation, our study findings suggest that walking is a practical intervention for patients with different cancer diagnoses at all treatment stages. This review provides clinicians with evidence of an effective sleep disturbance intervention to recommend to cancer patients. To avoid potential adverse effects resulting from exercise, lung function tests and exercise electrocardiography should be performed prior to any exercise interventions.

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Practice points

1. Walking is generally more effective than yoga at improving sleep in cancer patients.
2. Moderate-intensity walking can be advised in patients with different cancer diagnoses and at all treatment stages.
3. Walking and yoga are generally safe for most cancer patients; however, close monitoring and supervised exercise sessions are required for high-risk patients, especially those with cardiac or pulmonary comorbidities.

Research agenda

1. Study the optimal dosage of exercise interventions in the clinical setting using objective sleep pattern measuring tools, such as actigraphy or video recording, to precisely evaluate intervention effectiveness.
2. Include patients with cancer diagnoses other than breast cancer to increase generalizability.

3. Consider randomized clinical trials on walking and yoga in cancer patients with sleep disturbance to accurately evaluate the effectiveness of the two interventions.
4. Incorporate exercise intensity instruments, such as targeted heart rate and rating of perceived exertion, when designing yoga exercise randomized controlled trials to optimize efficacy.

Conflicts of interest

The authors do not have any conflicts of interest to disclose.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.smrv.2019.05.003.

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