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The effect of mind-body exercise on cognitive function in cancer survivors: A systematic review

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ABSTRACT

Objective: Cancer-related cognitive impairments experienced by cancer survivors cause many to seek non-pharmacological interventions to manage these symptoms. The aim of this systematic review was to evaluate the effects of one such intervention, mind-body exercise (MBE), on cognitive function in cancer survivors.

Design: Searches for relevant studies were conducted in four electronic databases, including PubMed, Embase, Scopus, and Web of Science. The Joanna Briggs Institute and Jadad scales were utilized to evaluate the quality of the selected studies.

Results: Eleven studies including 1,032 participants, published between 2006 and 2019, were selected for review based on specific inclusion criteria. Our results indicated that interventions including, yoga, tai chi, and qigong may improve objective and subjective cognitive function in cancer survivors.

Conclusion: Cancer survivors experiencing cognitive symptoms may benefit from participation in MBE. Adequately powered randomized controlled trials are required to establish the short- and long-term effects of MBE on cognitive functioning.

Keywords: mind-body exercise, cognitive function, cancer, systematic review

INTRODUCTION

Cancer is one of the major health problems around the world (Brunner, 2010; Larkey et al., 2016). Chemotherapy, radiotherapy, and biological therapies are some of the common methods of cancer treatment that can lead to improvements in progression-free survival. However, these treatment methods can cause significant side effects (Janelins et al., 2014). Specifically, numerous studies indicate that patients diagnosed with cancer and those who have received treatment often experience significant short-term and long-term cognitive impairment (Ahles et al., 2012; Hodgson et al., 2013; Jansen et al., 2011; Wefel & Schagen, 2012). Among patients who receive chemotherapy, it is estimated that 31-70% experience cognitive impairment (Stewart et al., 2008; Wefel et al., 2010).

Cancer-related cognitive impairment (CRCI) refers to the cognitive problems experienced by individuals with cancer, and most commonly includes deficits in attention, concentration, memory, processing speed, and executive function (Friedman et al., 2009; Vardy et al., 2008; Von Ah, 2015). CRCI may have negative consequences on quality of life, such as the ability to enjoy leisure activities, return to work or school, maintain social roles and relationships, and adhere to health regimens (Becker et al., 2015; Mayo et al., 2016; Potrata et al., 2010; Shilling & Jenkins, 2007). Causal mechanisms for cognitive impairment among cancer survivors may include direct effects on the central nervous system and indirect effects due to the body's immune response to both the cancer and cancer treatment. These effects may be compounded by a psychological response to a life-threatening illness such as anxiety and depression (Brière et al., 2008; Janelins et al., 2011; Wefel & Schagen, 2012).

Much attention has been focused on the use of non-pharmacological interventions for treating cognitive symptoms (Allen et al., 2018; Mayo et al., 2020), such as exercise (Campbell et al., 2020; Myers et al., 2019). With the recognized benefits of exercise on cancer-related symptoms and overall health, regular exercise is recommended for all cancer survivors (Campbell et al., 2019; National Comprehensive Cancer Network, 2014; Segal et al., 2017), although tailoring to an individual's ability and preferences is necessary.

Mind-body exercise (MBE) is defined by the dictionary of cancer terms as "a form of exercise that combines body movement, mental focus, and controlled breathing to improve

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strength, balance, flexibility, and overall health” (National Cancer Institute, 2021). MBE is considered to be a form of complementary therapy and has gained popularity in recent years within Western healthcare (Zeng et al., 2014; Zou, Wang, et al., 2017). Yoga, tai chi, and qigong are the most widely practiced forms of MBE likely due to ease of access and lack of special equipment requirements (Zou, Sasaki, et al., 2017; Zou et al., 2018). All three of these forms of MBE employ the common elements noted above, but vary in types and complexity of movement and postures, may or may not involve chanting or other sounds, and are on a continuum regarding associated levels of exertion (Derry et al., 2015; Larkey et al., 2016).

Among cancer survivors, MBE has been associated with positive effects on quality of life, physical fitness, fatigue, sleep quality, depression, anxiety and body mass index (Monti et al., 2008). In 2015, a narrative review of complementary and integrative interventions for CRCI provided an overview of MBE studies which suggested a positive effect of yoga, qigong, and tai chi on self-reported and objective cognitive function (Myers, 2015). Subsequently, two additional reviews added insight to this topic. Myers et al. (2018) conducted an integrative review of studies published prior to 2016. Of the 26 studies included in the review, only eight were comprised of MBE interventions, although the evidence was encouraging for a positive impact of MBE on cognitive function for cancer survivors. More recently, a 2018 systematic review including 29 trials of various exercise types indicated the likely benefit of MBE on cognitive function (Campbell et al., 2020). Neither of these recent reviews focused solely on MBE, so discussion of specific strengths, limitations, and outcomes for the MBE intervention studies was minimal. For clinicians interested in engaging in dialogue with patients regarding what is known about the impact of MBE on cancer-related cognitive symptoms, a systematic and comprehensive review focused on MBE studies still is needed.

Oncology nurses and other healthcare professionals (e.g., oncologists, neuropsychologists, and occupational therapists) have critically important roles in caring for cancer survivors to help them successfully meet the self-management needs for those individuals experiencing cognitive symptoms. Knowledge regarding the potential benefits of MBE on these symptoms is necessary to engage in evidence-based practice. To this end, we conducted a systematic review to synthesize the best available evidence on the effectiveness of MBE on CRCI. Our goal was to provide a resource that clinicians may use to learn about MBE and how it may be relevant for patients and survivors who are seeking non-pharmacological approaches for managing CRCI.

METHODS

Design and eligibility criteria

This systematic review is reported according to the Preferred Reporting records for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). Study inclusion and exclusion criteria were:

1. *Study design*: experimental (with or without a control group) or quasi-experimental studies, pilot studies, and feasibility studies;

2. *Intervention*: Inclusion of MBE, such as yoga, qigong, tai chi, while multi-modality interventions of which MBE was a component, such as mindfulness-based stress reduction, were excluded;
3. *Outcome*: Cognitive function measured using either objective (e.g., neuropsychological tests, clinician-administered assessment) or subjective (e.g., self-report) measures; and
4. *Population*: Adult cancer survivors during or following completion of cancer treatment while studies were excluded if they focused on adult survivors of childhood cancer, were not published in English, or were only available as conference abstracts.

Search strategy

A systematic search was conducted in PubMed, Embase, Scopus and Web of Science databases from their inception to September 7, 2020. Groups of keywords were chosen to identify relevant studies and search strings were limited to the title, abstract and keywords. Search terms were developed using the US National Library of Medicine’s Medical Subject Headings (MeSH) and Emtree from Embase database (see Table 1 for sample).

Selection of studies and data extraction

Records were entered into EndNote V.X8.1. Two researchers (FA and SS) independently screened each retrieved record by reviewing the title and abstract to identify studies relevant to the aims of the review. Disagreements regarding inclusion for full text review were resolved by a third researcher (MF). Subsequently, two researchers (FA and SM) independently conducted the full text review to ensure all studies met the eligibility criteria. Throughout the full text review process, a

Table 1

Example of Search String (PubMed)

(“cognitive impairment”[TIAB] OR “cognition impairment”[TIAB]
 OR “cognition Disorders”[TIAB] OR “cognitive Disorders”[TIAB]
 OR attention*[TIAB] OR memor*[TIAB] OR cognition*[TIAB]
 OR “problem solving”[TIAB] OR concentration*[TIAB])
 AND (“Mind-Body Therapies”[MH] OR “Mind Body
 Therapies”[TIAB] OR “Mind-Body Therapy”[TIAB] OR “Mind-
 Body Medicine”[TIAB] OR “Mind Body Medicine”[TIAB] OR
 yoga[TIAB] OR Pilates [TIAB] OR “tai chi” [TIAB] OR qigong
 [TIAB] OR meditation [TIAB] OR biofeedback[TIAB] OR
 hypnotherapy[TIAB] OR “guided imaginary” [TIAB] OR “cancer-
 related cognitive impairment”[TIAB] OR “chemotherapy-related
 cognitive impairment”[TIAB] OR chemobrain[TIAB] OR
 chemofog[TIAB]) AND (Neoplasms[MH] OR Neoplasms[TIAB]
 OR Neoplasia[TIAB] OR Neoplasias[TIAB] OR Neoplasm[TIAB]
 OR Tumor[TIAB] OR Tumors[TIAB] OR Cancer*[TIAB] OR
 Cancers[TIAB] OR Malignancy[TIAB] OR Malignancies[TIAB]
 OR “Malignant Neoplasms”[TIAB] OR “Malignant
 Neoplasm”[TIAB] OR “Benign Neoplasms”[TIAB] OR “Benign
 Neoplasm”[TIAB])

*Note: Search string was subsequently translated for Embase, Scopus and Web of Science.

third researcher (JM) resolved any disagreement related to eligibility. The following details were extracted for each included study: author, year of publication, country, study design, control group, sample characteristics, cancer site(s), intervention type, intervention format (length/ frequency/duration), whether cognitive function was the primary endpoint, measurement time-points, measures of cognitive function, and results related to cognitive function.

Quality assessment

The Cochrane Risk of Bias Tool (Higgins et al., 2021) was used to assess the quality of the RCTs. The domains for assessment included random sequence generation and allocation concealment (selection bias), blinding (performance bias and detection bias), incomplete outcome data (attrition bias), selective outcome reporting (reporting bias), and other possible sources of bias (timing of outcome assessment, no significant differences between groups at baseline, the suitable rationale for the control group). All domains were subscribed as “Low” (low risk of bias), “High” (high risk of bias), or “Unclear” (insufficient information provided to assess bias) (Higgins et al., 2021).

Quasi-experimental studies were assessed using the Joanna Briggs Institute Critical Appraisal Checklist for Quasi-Experimental Studies (JBI). This checklist includes nine

questions to evaluate a study’s design and validity of the results. Higher scores indicate higher quality studies. In particular, the checklist is designed to assess causal relationships, similarity of participants between compared groups, the existence of a control group, the existence of pre- and post-intervention measurements, the procedures of any follow-up measures, the measure of the outcomes included in any comparisons, the reliability of the outcomes, and the appropriateness of the statistical analysis. Each critical appraisal checklist item was evaluated as yes, no, unclear, or not applicable (Joanna Briggs Institute, 2016). All quality assessments were conducted by two authors (FA and SS) and any disputes were resolved by a third (MF).

RESULTS

Study selection

Search queries of the target databases yielded 3,755 relevant items. After removing 1,265 duplicates, 2,490 records remained. An additional eight records were identified through forward search. Following the title and abstract screening, 18 articles were considered eligible for full-text analysis. Of these, four did not meet the inclusion criteria and were excluded, as were three conference abstracts. A total of 11 studies met the eligibility criteria and were included in this review (Figure 1).

Figure 1

Study selection process

Study characteristics

The 11 selected studies were nine RCTs (Culos-Reed et al., 2006; Derry et al., 2015; Janelins et al., 2016; Larkey et al., 2016; Lötze et al., 2016; Myers et al., 2019; Oh et al., 2012; Pasyar et al., 2019; Vadiraja et al., 2009), one feasibility study

(Komatsu et al., 2016), and one single-arm pilot study (Reid-Arndt et al., 2012) (Table 2). These 11 studies involved 1,032 cancer survivors, were published between 2006 and 2019, and were conducted primarily in the USA ($n = 5$). The sample sizes ranged from 23 to 328 individuals and ages ranged between 42

Table 2

Characteristics of Included Studies

Author (Year)	Country	Design	Sample	MBE Intervention	Measure of Cognitive Function		Timing of assessments	Findings related to cognitive function	Cognitive function as primary endpoint
					Subjective	Objective			
Yoga									
Pasyar (2019)	Iran	Randomized pilot study Usual Care	During TX n = 40 Female 100% Mean age=51 Breast cancer 100%	Yoga 8 weeks (2X/ week) 60' per session plus home practice (1X/ week)	EORTC QLQ- C30 CF	n/a	T1: Baseline T2: 4 weeks T3: Post- intervention (8 week)	NS at 4 weeks and 8 weeks post- intervention	No
Janelins (2016)	USA	RCT Usual Care	Post-TX n = 328 Female 96% / Male ~4% Median age= 54 Breast cancer 77% Hematological 7% Gastrointestinal 4% Gynecological 4% Other 8%	Hatha and restorative program Total 8 sessions (2X/ week) 75' per session	MDASI -Memory difficulty	n/a	T1: Baseline T2: Post- intervention	Improved self-reported memory post- intervention	No
Komatsu (2016)	Japan	Feasibility study, single arm	During TX n = 18 Female 100% Mean age=43.9 Breast cancer 100%	Yoga 4 weeks home practice (3 x 15' course choices)	CFQ	n/a	T1: Baseline T2: Post- intervention	NS post- intervention	Yes
Lotzke, (2016)	Germany	RCT Active control (exercise)	During TX n = 92 Female 100% Mean age=51 Breast cancer 100%	Lyenger Yoga 12 weeks (1X/ week) 60' per session plus home practice (2X/ week for 20')	EORTC QLQ- C30 CF	n/a	T1: Baseline, T2: Post- intervention T3: 3-month follow-up	NS post- intervention or at 3-month follow-up	No
Derry (2015)	USA	RCT Waitlist control	Post-TX n = 200 Female 100% Mean age=51.6 Breast cancer 100%	Hatha yoga 12 weeks (2X/ week) 90' per session plus encouraged home practice	BCPT	n/a	T1: Baseline T2: Post- intervention T3: 3-month follow-up	NS post- intervention Improved self-reported function at 3 months post- intervention	Yes
Vadiraja (2009)	India	RCT Active control (supportive therapy)	During TX n = 75 Female 100% Mean age= 47 Breast cancer 100%	Yoga 6 weeks (3X/ week) 60' per session plus self- practice for the remaining days of the week	EORTC QLQ- C30 CF	n/a	T1: Baseline T2: Post- intervention	Improved self-reported function post- intervention	No
Culos- Reed (2006)	Canada	Randomized pilot study Waitlist control	Post-TX n = 38 Female 95%/Male 5% Mean age=51 Breast cancer 85% Other cancers 15%	Yoga 7 weeks (1X/ week) 75' per session	SOSI -cognitive disorganization	n/a	T1: Baseline T2: Post- intervention	NS	No

continued...

Myers (2019)	USA	Randomized pilot study Two active control groups	Post-TX <i>n</i> = 50 Female 100% Mean age=53.68 Breast cancer 100%	Qigong 8 weeks (1X/week) 60' per session plus home practice (twice daily for 15')	FACT-Cog PROMIS Cognitive Function: General Concerns and Abilities scales	RAVLT (Memory) F-A-S (Verbal fluency) TMT A (Processing speed) TMT B (Executive function)	T1: Baseline T2: Post-intervention T3: 4 weeks post-intervention	Post-intervention improvements in self-reported cognitive function (FACT-Cog and PROMIS scales)	Yes
Larkey (2016)	USA	Randomized pilot study Active control	Post-TX <i>n</i> = 87 Female 100% Mean age=59 Breast cancer 100%	Tai chi/Qigong 12 weeks (2 weeks @ 2X/week then 10 weeks @ 1X/week) 60' per session plus home practice (5 days/week for 30')	FACT-Cog	WAIS-III Digit Span (attention) Letter-Number Sequencing (working memory)	T1: Baseline T2: Post-intervention T3: 3 months follow-up	NS compared to active control	No
Oh (2012)	Australia	RCT Usual Care control	During TX <i>n</i> = 81 Female 50% / Male 50% Mean age = 62 Breast cancer 31% Colorectal cancer 23% Prostate cancer 10% Gastric cancer 10% Lung cancer 9% Other 16%	Medical Qigong 10 weeks (1X/week) 90' per session	FACT-Cog EORTC QLQ-C30 CF	n/a	T1: Baseline T2: Post-intervention	Improved self-reported function on both measures post-intervention	Yes
Reid-Arndt (2012)	USA	Pilot study, single arm	Post-TX <i>n</i> = 23 Female 100% Mean age= 62 Breast cancer 70% Ovarian 13% Other 17%	Tai Chi 10 weeks (2/week) 60' per session	MASQ	RAVLT (Memory) TMT B, Stroop test (Executive function) COWAT (verbal fluency) WAIS-III Digit Span, Digit Symbol TMT A (Attention)	T1: Baseline T2: Post-intervention	Improved self-reported verbal and visual memory, and improved performance in delayed memory, verbal fluency, attention, and executive functioning post-intervention	Yes

NS non-significant or no change, **TX** treatment, **MDASI** MD Anderson Symptom Inventory, **RAVLT** Rey Auditory Verbal Learning Test, **BCPT** cognitive subscale on the Breast Cancer Prevention Trial, **MASQ** Multiple Ability Self-Report Questionnaire, **FACT-Cog** Functional assessment of cancer therapy cognition, **COWAT** Controlled Oral Word Association Test, **EORTC-QLQ C30 CF** European Organization for Research and Treatment of Cancer-Quality of life C30 Cognitive Functioning Subscale, **CFQ** Cognitive Failures Questionnaire, **SOSI** Symptoms of Stress Inventory, **WAIS-III** Wechsler Adult Intelligence Scale-III, **TMT** Trail Making Test, **PROMIS** Patient-Reported Outcomes Measurement Information System,

and 62 years. The majority of participants were female patients with breast cancer (*n* = 885, 85.8%), though four studies also enrolled patients with other cancer types including hematological, gastrointestinal, gynecological, prostate, and lung cancers (Culos-Reed et al., 2006; Janelsins et al., 2016; Oh et al., 2012; Reid-Arndt et al., 2012). The effectiveness of MBE interventions was evaluated during (*n* = 5) or after (*n* = 6) the completion of cancer treatment.

MBE and cognitive function

Yoga (seven studies)

Yoga was the intervention of interest in seven studies. Labeling of the yoga interventions varied across the studies, with three recognized methods of yoga represented. These included: *Hatha Yoga* (Derry et al., 2015), *Combination Hatha and Restorative Yoga* (Janelsins et al., 2016), and *Iyengar-yoga* (Lötze et al., 2016). The remaining yoga interventions involved

combinations of yoga elements, including: relaxation, meditation, deep breathing, and low-intensity postures (Komatsu et al., 2016), stretching and breathing exercises, gentle stretching and strengthening exercises of specific muscle groups (Culos-Reed et al., 2006; Pasyar et al., 2019; Vadiraja et al., 2009). Yoga programs ranged from 4 to 12 weeks in duration. Sessions were delivered in a group-based, in-person format, at a frequency of once or twice a week, lasting 15 to 90 minutes each. In five studies, in-person sessions were supplemented with home-based practice (Derry et al., 2015; Komatsu et al., 2016; Lötze et al., 2016; Pasyar et al., 2019; Vadiraja et al., 2009). One was supported by an educational DVD (Pasyar et al., 2019).

All seven studies assessed cognitive function via self-report at baseline and post-intervention, with six comparing outcomes to either a waitlist control (Culos-Reed et al., 2006; Derry et al., 2015), standard of care (Janelins et al., 2016; Pasyar et al., 2019), or active control group (Lötze et al., 2016; Vadiraja et al., 2009). Three studies collected additional follow-up at one to two months (Pasyar et al., 2019) and three months (Derry et al., 2015; Lötze et al., 2016) after the intervention. None of the studies measured cognitive outcome using objective measures.

Three of the four RCTs (Derry et al., 2015; Janelins et al., 2016; Vadiraja et al., 2009) reported significant improvement in self-reported cognitive functioning when compared against usual care or an attention control. Self-reported memory difficulty was significantly reduced after eight bi-weekly sessions of group-based combination Hatha and Restorative Yoga in an RCT comprised of 328 survivors (primarily breast cancer); a 19.2% improvement in the yoga group was observed compared with a 5.4% improvement in the usual control group ($p < .05$) (Janelins et al., 2016). In an RCT of 75 women with breast cancer undergoing adjuvant chemotherapy, self-reported cognitive functioning improved in the intervention group after a six-week yoga program, but not in the active control group who received six weeks of brief supportive therapy with a social worker ($ES = 0.48$, $p = .003$) (Vadiraja et al., 2009). In another trial of 200 breast cancer survivors, those randomized to a 12-week group-based Hatha yoga program also demonstrated 23% lower scores on the measure of self-reported cognitive problems, as compared to wait-list controls ($p = .003$). However, this difference was only observed three months after the intervention, hypothesized by the study authors to be linked to participants' continued engagement in home-based yoga practice following completion of the 12-week program (Derry et al., 2015). All three studies demonstrated moderate to high adherence to the programs. In contrast, in an RCT of women with breast cancer who were undergoing treatment, weekly yoga sessions were not associated with improvement in self-reported cognitive functioning compared to weekly sessions of conventional exercise, though there was high dropout rate and limited uptake of the interventions among the participants (Lötze et al., 2016).

Qigong /Tai Chi (4 studies)

Qigong and tai chi studies were reviewed together as tai chi is a more complex form of Qigong (Larkey et al., 2016). Two

randomized studies (Myers et al., 2019; Oh et al., 2012) evaluated qigong programs. The total duration of the programs varied from 8 to 10 weeks, with sessions occurring once or twice a week, lasting 60 to 90 minutes each. Two forms of qigong were studied, including *Six Healing Sounds*, which involves the coordination of movement and breathing patterns with particular sounds and is the most common form of qigong (Myers et al., 2019) and *Medical qigong*, which involves practice of coordinated gentle exercise and relaxation through breathing and meditation (Oh et al., 2012). Myers et al. (Myers et al., 2019) conducted a three-arm RCT with 50 breast cancer survivors. Participants were randomized to Qigong, Gentle Exercise (same movements/postures as Qigong, but without the mindfulness component) and active control (breast cancer support) groups. Participants in the Qigong and Gentle exercise groups both reported improvement in two measures of cognitive function between baseline and completion of the intervention. The improvement in the Qigong group was significantly greater than those in the active control group ($p = .01$ to $.04$). The Qigong group demonstrated significant improvement on a test of processing speed compared to both other groups ($p = .007$). Only the Qigong group improved on a test of executive function. While not significant, the effect size was moderate (Cohen's $d = -0.43$). In another RCT with 81 breast cancer survivors, participants in the Medical Qigong group, reported significant improvement in cognitive function ($p = 0.014$) (Oh et al., 2012).

Two pilot studies also examined tai chi interventions, with mixed results. A single-arm study evaluated a tai chi program based on the yang style of tai chi which emphasizes slow movements (Reid-Arndt et al., 2012). In this small study of 23 women, sessions were 60-minutes in length and held twice a week for 10 weeks. Statistically significant changes in self-reported verbal and visual memory, as well as objectively measured delayed memory, verbal fluency, attention, executive functioning, verbal memory, and visual memory were demonstrated post-intervention (all p values $< .05$). In contrast, a randomized pilot trial assessed the effect of a 12-week combination tai chi/qigong program to an active control of sham qigong (SQG), comprised of similar gentle movements but without the focus on breathing and meditation (Larkey et al., 2016). In this study of 87 breast cancer survivors, an improvement in both self-reported and objectively measured cognitive functioning was observed in both groups after the 12-week intervention. (all p values < 0.001).

Measurement of cognitive functioning

Heterogeneity in the measurement of cognitive functioning was noted across the 11 studies reviewed (Table 2). Five of the studies focused on cognitive function as a primary endpoint. Of these, only two employed both subjective and objective measures of cognitive function. One additional study included both types of measures, however cognitive function was an exploratory endpoint. Pertinent objectively measured cognitive domains included verbal memory, verbal fluency, processing speed, executive function, and attention (Larkey et al., 2016; Myers et al., 2019; Reid-Arndt et al., 2012). Nine different self-report measures were used. Of these, five include cognitive

function as a sub-scale or single item. Only the FACT-Cog (Functional Assessment for Cancer Therapy Cognition) and PROMIS (Patient Reported Outcomes Management Information Systems Cognitive Function General Concerns and Abilities) instruments, used in two of the studies (Myers et al., 2019; Oh et al., 2012), were developed specifically for cancer survivors.

Quality assessment

Among nine RCTs, five studies (56%) reported adequate random sequence generation (Table 3) (Derry et al., 2015; Janelsins et al., 2016; Oh et al., 2012; Pasyar et al., 2019; Vadiraja et al., 2009), but only four studies (45%) described the allocation concealment process (Derry et al., 2015; Janelsins et al., 2016; Myers et al., 2019; Pasyar et al., 2019). Only two trials (22%) had a low-risk performance bias by masking study personnel and participants (Larkey et al., 2016; Pasyar et al., 2019). All of the nine studies (100%) had a low risk of detection bias based on masking of outcome assessment (Derry et al., 2015; Janelsins et al., 2016; Larkey et al., 2016; Lötze et al., 2016; Myers et al., 2019; Culos-Reed et al., 2006; Oh et al., 2012; Pasyar et al., 2019; Vadiraja et al., 2009). The risk of bias due to incomplete outcome data was high in four trials (45%) (Janelsins et al., 2016; Myers et al., 2019; Pasyar et al., 2019; Vadiraja et al., 2009) because of the number of dropouts at the completion of the program (Myers et al., 2019; Oh et al., 2012; Vadiraja et al., 2009), or reasons not reported (Janelsins et al., 2016). Reporting bias was high in four trials (45%) (Derry et al., 2015; Janelsins et al., 2016; Culos-Reed et al., 2006; Vadiraja et al., 2009). Acceptable methodological quality was noted for all the quasi-experimental studies. These studies scored positively in all domains of the JBI tool with the exception of employing a control group (Komatsu et al., 2016; Reid-Arndt et al., 2012).

DISCUSSION

This review summarizes the current evidence related to effectiveness of MBE on cognitive impairment for cancer survivors during or after the completion of cancer treatment, with studies focused on the most common methods of MBE (yoga, qigong, and tai chi). Our review affirms and extends those of Myers (2015, 2017) and Campbell (2019) by further demonstrating the potential benefits of MBE on CRCI, and providing greater depth in examining the results, strengths, and limitations of the current body of evidence for clinicians who may be working with survivors interested in these modalities. While primarily based on self-report measures of cognitive functioning, most of the included studies report positive effects of MBE on cognitive function (Derry et al., 2015; Janelsins et al., 2016; Myers et al., 2019; Oh et al., 2010; Reid-Arndt et al., 2012; Vadiraja et al., 2009).

Yoga involves muscular activity and a focus on awareness of oneself in which an individual's physical, mental, and spiritual components integrate to enhance physical and mental health (Cramer et al., 2012; Derry et al., 2015). Of the studies that evaluated the effect of yoga, results from three RCTs demonstrated improvement in self-reported cognitive function after participation in yoga programs as compared to controls (Derry et al., 2015; Janelsins et al., 2016; Vadiraja et al., 2009). The other studies were limited by either poor adherence to the yoga intervention or were pilot studies. These findings suggest that the benefits of yoga on cognitive functioning are likely greater when engaging regularly in yoga practice over a sustained period of time.

As with yoga, both tai chi and qigong involve repeated practice of movements and postures in synchrony with a focus on breathing and meditation. Qigong involves simpler and more repetitive movements than tai chi and may be easier for patients to learn (Larkey et al., 2015). Both tai chi and qigong

Table 3

Cochrane Risk of Bias Assessment for RCTs

Study	Random sequence generation	Allocation concealment	Masking of participants/personnel	Masking of outcome assessors	Incomplete outcome data	Selective reporting	Other bias
Pasyar (2019)	●	●	●	●	●	●	●
Myers (2019)	●	●	●	●	●	●	●
Janelsins (2016)	●	●	●	●	●	●	●
Lötze (2016)	●	●	●	●	●	●	●
Larkey (2016)	●	●	●	●	●	●	●
Derry (2014)	●	●	●	●	●	●	●
Oh (2012)	●	●	●	●	●	●	●
Vadiraj (2009)	●	●	●	●	●	●	●
Culos-Reed (2006)	●	●	●	●	●	●	●

Other bias (timing of outcome assessment, not significant differences between groups at baseline, the suitable rationale for the control group). Red ● = high risk of bias; green ● = low risk of bias; yellow ● = unclear risk of bias.

Table 4*Quality Assessment for Quasi-experimental Studies (Joanna Briggs Score)*

Items	Reid-Arndt (2012)	Komatsu (2016)
Is it clear in the study what is the 'cause' and what is the 'effect' (i.e., there is no confusion about which variable comes first)?	Yes	Yes
Were the participants included in any comparisons similar?	Yes	Yes
Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	Yes	Yes
Was there a control group?	No	No
Were there multiple measurements of the outcome both pre and post the intervention/exposure?	Yes	Yes
Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	Yes	Yes
Were the outcomes of participants included in any comparisons measured in the same way?	Yes	Yes
Were outcomes measured in a reliable way?	Yes	Yes
Was appropriate statistical analysis used?	Yes	Yes

are ancient forms of Chinese exercises that involve slow movements, deep and controlled breathing with meditation. Results of the studies that assessed the effect of qigong and tai chi were generally promising regarding the potential benefits of these interventions on cognitive function among individuals with cancer. These results affirm the findings from the review of Campbell et al. (2020) that exercise can prevent significant decrease in performance on cognitive tasks. As well, our results also affirmed evidence from studies that demonstrated a positive effect of tai chi (Wu et al., 2013) and qigong (Jin et al., 2020; Ladawan et al., 2017) on cognitive functions in non-cancer settings. Further studies in populations outside of breast cancer, with an appropriate sample size, is important to reach conclusive results.

Mind-body therapies aid in enhancing the connection between the mind and body by engaging controlled body movements with rhythmic breathing and focused attention (Vadiraja et al., 2009). Cancer and cancer treatments may alter neurogenesis within the hippocampus and pre-frontal cortex and increase products of inflammation (e.g., C-reactive protein, pro-inflammatory cytokines) leading to cognitive impairment (Moss et al., 2012; Newberg et al., 2014; Noble et al., 2010; Pierce et al., 2009; Seruga et al., 2008). Exercise has been

linked to enhancement of factors associated with brain health, such as brain derived neurotrophic factor, and has been shown to reduce inflammatory cytokines associated with the body's immune response to the cancer and cancer therapy (Erickson et al., 2011; Hillman et al., 2008; Stillman et al., 2016). Physical activity can influence cognitive function by increasing cerebral blood flow, neurogenesis, and neurotrophic factors (Hillman et al., 2008). Yoga and medical qigong have been associated with reduced inflammation in women treated for breast cancer (Kiecolt-Glaser et al., 2014; Oh et al., 2012; Yeh et al., 2006).

As a form of exercise incorporating meditative practices that include controlled regulation of breathing and control of thoughts and feelings, the meditative aspects of MBE may additionally downregulate the stress response through the hypothalamic-pituitary-adrenal axis and sympathetic nervous system. Such downregulation has demonstrated evidence of improving working memory and processing speed in non-oncology populations (Innes & Selfe, 2014; Mangani et al., 2020; Yeung et al., 2018). Therefore, engaging in mind-body therapies which may alter mechanistic properties of the brain may improve cognitive function for cancer survivors. MBE may also contribute to reducing symptom distress in combination with other interventions. For example, mindfulness-based stress reduction (MBSR) is a mindfulness training program that integrates yoga as one of its components (Kabat-Zinn, 2005), and there is evidence to support its positive effects on distress, quality of life and cognitive functioning (Johns et al., 2016; Schell et al., 2019). Overall, our research supports the potential benefit of integrating MBE as part of supportive care interventions targeted to alleviating cognitive symptoms.

LIMITATIONS

Our analysis was limited due to the small number of studies meeting the inclusion criteria and restriction to those reported in English. The studies included in the review were heterogeneous in terms of study design, intervention components (e.g., type, frequency, duration), and measurement instruments used, thus complicating our ability to draw conclusions. For instance, most studies included in this review employed only subjective measures (self-reported) of cognitive functioning. Self-reported outcomes may be biased by social desirability and expectations of an intervention effect. Moreover, specific to studies of cognitive functioning, subjective measures correlate poorly with objective measures, but provide important information about the experience of cognitive impairment, as patient-reported outcomes (Dhillon et al., 2018; Savard & Ganz, 2016). Objective tests, which are more often considered the gold standard for assessing cognitive function (Hutchinson et al., 2012) were not used in most of the studies in this review, preventing any conclusions about the impact of MBE on objective cognitive performance.

Future studies including both subjective and objective measures (such as those recommended by the International Cognition and Cancer Task Force) (Wefel et al., 2011) for assessing cognitive function may offer a more comprehensive understanding of the effects of MBE on CRCI. Additionally, the reviewed studies were focused primarily on the short-term

effects of these interventions among women with breast cancer, did not all assess cognitive function as the primary outcome, or use self-report instruments specifically designed to focus on cognitive function. These approaches limit the conclusions that may be drawn from these studies. Future research should include diverse cancer populations, specifically designed to assess the MBE for cognitive function, and include long-term follow-up to assess the lasting effects of MBE on CRCI.

Among the studies in this review, a priori power calculation was noted for only five (Derry et al., 2015; Larkey et al., 2016; Lötzke et al., 2016; Pasyar et al., 2019; Vadiraja et al., 2009) with Derry's sample size ($n = 200$) large compared to other studies in this review. Of the other studies where power calculation was not estimated (Janelins et al., 2016; Komatsu et al., 2016; Myers et al., 2019; Culos-Reed et al., 2006; Oh et al., 2012; Reid-Arndt et al., 2012), only the Janelins' study had a large sample of cancer survivors ($n = 328$). Overall, most of the eleven studies involved small sample sizes which affected the power of the results. Adequately powered studies, and in populations outside of breast cancer, may help to clarify the relative benefits of different types of yoga and the most appropriate dose.

Other limitations include the potential for sample bias (individuals likely volunteered and were already self-motivated to engage in MBE) and lack of 3-arm studies. In particular, three-arm studies are needed in psychosocial intervention research as an intervention of any type could yield a therapeutic response in comparison to a control group (Evans, 2010). Additionally, we identified risks of bias in the included studies, particularly related to lack of blinding and incomplete data on outcomes. Future trials of mind-body exercise should address these methodological limitations to strengthen the conclusions that can be made about the effect of these exercises on cognitive function.

Implications for practice

Oncology nursing is one of the most suitable nursing fields to safely integrate complementary medicine into

nursing practices and care (Admi et al., 2017). Oncology nurses are well-positioned to identify cancer survivors with clinically significant cognitive decline and should carefully assess patients for potential indicators of cognitive impairment (Jansen, 2013). Non-pharmacological approaches, such as yoga, tai chi, and qigong may be considered minimally invasive, cost-effective approaches for managing and improving cognitive function in patients with cancer. (National Comprehensive Cancer Network, 2014; Von Ah et al., 2014). Ongoing education regarding the potential use of these modalities in the self-management of cognitive symptoms, to facilitate evidence-based discussions with clients who may be interested in engaging in such programs, is important for oncology nurses as well as other disciplines providing care to cancer survivors. Due to the important role of nurses and health care teams in assessing cognitive problems in patients with cancer, providing access to non-pharmacological interventions and related clinical trials is crucial to advancing the science of evidence-based interventions for preventing cognitive decline and improving cognitive function.

CONCLUSION

The results of this systematic review suggest that MBE may offer benefits for subjective and objective cognitive function among cancer survivors. Cancer survivors should be encouraged to take part in research to advance the state of knowledge about the use of MBE to prevent or mitigate the cognitive effects of cancer and cancer therapy. Adequately powered randomized controlled trials in diverse cancer populations are required to establish the short- and long-term effects of MBE on cognitive functioning.

DECLARATION OF COMPETING INTEREST

All authors declare that they have no competing of interest.

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