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REVIEW ARTICLE

Effects of exercise on the quality of life in breast cancer patients: a systematic review of randomized controlled trials

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Abstract

Purpose The purpose of this study was to conduct a systematic review to assess the effect of exercise on the quality of life among people with breast cancer.

Methods We conducted a systematic review using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. The Cochrane Library, PubMed, EMBASE, Web of Science, CINAHL, and four Chinese databases were searched for studies published until January 2018. The review included all randomized controlled trials that evaluated the effect of exercise on quality of life compared with that of usual care for people with breast cancer. Two reviewers independently assessed the quality of all the included studies using the *Cochrane Handbook for Systematic Reviews of Interventions*.

Results In total, 36 studies (3914 participants) met the inclusion criteria. We divided the exercise into three modes: aerobic, resistance, and a combination of aerobic and resistance. All three modes of exercise intervention showed a significant effect on quality of life between groups.

Conclusions Exercise is a safe and effective method of improving the quality of life in patients with breast cancer. In particular, combined training was associated with a significant improvement in quality of life. In future research, more high-quality, multicenter trials evaluating the effect of exercise in breast cancer patients are needed.

Keywords Breast cancer · Physical activity · Quality of life · Systematic review

Abbreviations

BCS	Breast cancer subscale
BIRS	Body Image and Relationships Scale
EORTC QLQ-BR23	European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Breast
EORTC QLQ-C30	European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Core 30
ES	Effect Size
FACT-A	Functional Assessment of Cancer Therapy-Anemia scale
FACT-B	Functional Assessment of Cancer Therapy-Breast questionnaire
FACT-G	Functional Assessment of Cancer Therapy-General
FWB	Functional well-being
HRQOL	Health-related quality of life
MCS	Mental health
PCS	Physical Component Summary
QOL	Quality of life
RCT	Randomized controlled trials
SF-36	36-item Short-Form Health Survey
TOI-An	Trial Outcome Index-Anemia

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Introduction

Worldwide, breast cancer is the most frequently diagnosed cancer and the leading cause of cancer death among women; more than 1.3 million women are diagnosed with breast cancer every year [1]. In the USA, the 5-year relative survival rate is 90.6% [2]. As the survival rate of breast cancer increases, many breast cancer patients are confronted with cancer-related side effects, with severe impact on physical, psychological, social, and spiritual aspects of quality of life (QOL) [3]. In addition, significant treatment-related sequelae may persist for

many years and continue to influence long-term quality of survival [4]. Consequently, there is an imperative for increased attention to their quality of survivorship.

The benefits of exercise intervention on QOL for patients of breast cancer are increasingly attracting attention. Exercise interventions may be particularly appropriate for cancer patients because they have the potential to improve physical and psychological functioning, including QOL [5, 6]. There is evidence that exercise improves lean body mass, adiposity, and muscular strength in breast cancer patients, which has been associated with improved physical function and QOL [7]. Exercise prescribed two to three times a week, during or after chemotherapy, has been shown to improve QOL [8, 9]. Recent reviews on cancer and exercise reported that participation in an exercise program during and after treatment improved QOL and health status, and decreased side effects [10].

There have been several published meta-analyses of the effect of exercise interventions on the QOL of breast cancer patients. Duijts et al. [10] conducted a comprehensive meta-analysis of the effects of physical exercise on QOL for both breast cancer patients and survivors, but included randomized controlled trials (RCTs) only up to 2009. A meta-analysis published in 2013 evaluated the effect of exercise training on QOL for breast cancer survivors only [11]. This study supported the idea that exercise interventions have statistically significant effects on overall QOL. However, in recent years, there have been an increasing number of trials of motion interventions for breast cancer patients. Therefore, we undertook the present systematic review to evaluate the most recent and convincing evidence.

Methods

Protocol and registration

The review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines [12].

Search strategy

A thorough search (computerized and manual) was undertaken to identify all relevant literature. We searched the Cochrane Library, PubMed, EMBASE, Web of Science, CINAHL, and four Chinese databases (CBM, CNKI, WanFang Data, and VIP). The search comprised the terms "breast cancer" and "quality of life", with exercise intervention terms such as "exercise," "exercise therapy," "aerobic exercises," "physical activity," "resistance training," "running," "walking," "sports," "yoga," "tai chi," and "qigong." The search was limited to human studies. All searches were from database inception to January 17, 2018. We also performed a manual search of references cited by the original published studies and relevant review articles. A search of Google Scholar was conducted using the same key words to identify any additional relevant articles.

Eligibility criteria

Types of studies

Only RCTs were included in the present review. No publication date restrictions were imposed on the initial search.

Participants

The participants were adults (> 18 years) diagnosed with breast cancer.

Interventions

The inclusion criteria were as follows: (1) the intervention group underwent exercise intervention; and (2) the control group did not undergo any exercise intervention. However, studies in which exercise training was part of an intervention with multiple components (e.g., combined with a diet intervention) were excluded.

Outcomes

The studies were required to report QOL as outcome measure.

Study selection

The eligibility assessment was performed by two independent reviewers. All papers identified using the search strategy were assessed for eligibility by evaluating their titles and/or abstracts. If insufficient information was available to evaluate an article, then a full-text version was obtained and reviewed by two independent reviewers. Disagreements were resolved by discussion with a third reviewer. When insufficient information or data were available in the included articles, the authors were contacted to obtain additional information if possible.

Quality assessment

The quality of included studies was assessed independently by two authors. The quality items assessed were random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other biases. Each trial was classified into low risk, unclear,

or high risk following the criteria set out in the *Cochrane Handbook for Systematic Reviews of Interventions* [13] with the aim of estimating the selection, performance, attrition, and detection biases.

Data extraction and analysis

The data were extracted from the included articles using a data extraction form. Sample sizes were collected. Details on exercise interventions were recorded including the exercise type, exercise session, frequency, and program duration. The effects of the exercise training on QOL were collected, including QOL measures and the study result. One investigator performed the data extraction, which was verified by a second investigator. In accordance with the *Cochrane Handbook for Systematic Reviews of Interventions*, a meta-analysis was not performed because of the heterogeneity due to a variety of different measurement tools.

Results

Study searching and selection

We identified 4133 studies based on the database searches, and two new studies were retrieved after reviewing the bibliographies of the full-text papers collected during the initial search. After removing duplicates and studies that did not fulfill the criteria, 36 studies [8, 14–49] with 3914 participants were included in the final analysis (Fig. 1).

Description of studies

The characteristics of the included articles are presented in Table 1. Sample size ranged from 20 [25] to 460 [34] participants. The duration of the training sessions varied from at least 15 min [18, 33] to 90 min [8, 26, 40, 46, 49], excluding three studies [16, 24, 39] that did not report the duration of the training sessions. The frequency of the training sessions varied from at least once a week [8, 33, 36] to seven times a week [32], excluding one study [21] that did not report the frequency of the training sessions. The duration of the total training period varied from 4 weeks [17, 47] to 8 months [44], with the exception of one study [16] that did not report the duration of the total training period. We divided the exercise into three modes: aerobic, resistance, and a combination of aerobic and resistance (Table 1). Among the included studies, four studies [16, 24, 37, 42] compared two intervention types with a control group, and three studies [14, 43, 44] reported two forms of the same exercise intervention trial.

Quality assessment

All 36 studies were included in the quality assessment (Fig. 2). Most had low risk of bias. Major sources of risk of bias were from lack of blinding study subjects or research personnel, incomplete outcome data, and blinding of outcome assessment. Of the 36 trials, most studies described the method of randomization and their methods of sequence generation or allocation concealment. Two studies did not provide the reason for loss of follow-up; this may induce attrition bias. Due to the nature of exercise interventions, it may be difficult to blind participants to intervention delivery.

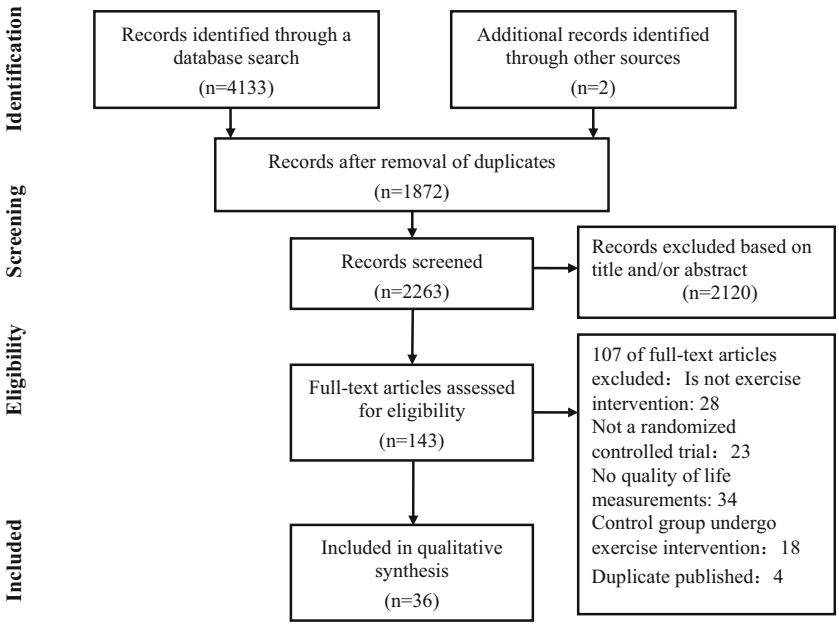

Fig. 1 Flowchart of the selection of the clinical trials

Table 1 Characteristics of included studies

First author (year)	Sample	Intervention characteristics			Outcome		
		Exercise	Exercise session duration, frequency	Program duration	Quality of life measurements	Result	Dropout
Aerobic							
Courneya[1] [8]	IG = 25 CG = 28	Recumbent or upright cycle ergometers	20 min to 40 min, 3×/week, 70%–75%VO 2_{max}	15 weeks	FACT-B	Significant between-group difference for Overall QOL ($P = 0.001$)	IG = 1
Cadmus [14]	IG = 25/37 CG = 25/38	Home-based walking	30 min,5×/week 60%–80% of HR_{max}	6 months	FACT-B and SF-36	No significant between-group difference	IG = 3/3 CG = 2/5
Basen-Engquist [15]	IG = 35 CG = 25	Walking	90 min, 1–16 weeks: 1×/week 17–24 weeks: 1×/fortnight	6 months	SF-36	Significant between-group difference for general health ($p = 0.006$) and bodily pain ($p = 0.020$).	IG = 2 CG = 7
Courneya[2] [16]	IG = 78 CG = 82	Cycle ergometer, treadmill, or elliptical	15 to 35 min, 3×/week, 60–80% VO 2_{max},	NR	FACT-A	Significant improvement in aerobic fitness	IG = 4 CG = 9
Fillion [17]	IG = 48 CG = 46	Walking	60 min, 4×/week,	4 weeks	SF-12	Significant between-group difference for mental quality of life($p = 0.04$)	IG=4[a] CG=3[a]
Hornsby [18]	IG = 10 CG = 10	Supervised aerobic cycle ergometry	15–20 min 60% of VO_{2max} to 40–60 min 70–100% of VO_{2max}, 3×/week	12 weeks	FACT-B	No significant between-group difference	1
Mustian [19]	IG = 11 CG = 10	Yang-style tai chi chuan using the 15-move short form	60 min,3×/week	12 weeks	SF-36 and FACIT–F	Significant improved in total HRQOL ($P = 0.045$),physical functioning($P = 0.030$),physical role limitations($P = 0.023$), social functioning ($P = 0.020$), and general mental health ($P = 0.03$)	IG = 2
Loudon [32]	IG = 15 CG = 13	Satyananda Yoga tradition	75 min, everyday	8 weeks	LYMQOL	Significant improvement between-group for the QOL sub-scale of symptoms ($p = 0.038$)	IG = 3 CG = 2
Voogd [33]	IG = 25 CG = 28	Exercise training on bicycle ergometers	15–35 min, 3×/week, 70–75%VO_{2max},	15 weeks	FACT-B	Significant between-group difference ($P < 0.01$)	NR
Jacobsen [34]	460	Home-based walking	20–30 min, 3×/week, 50–75%HRR	12 weeks	SF-36 and CES-D	Significant between-group difference for depressive symptoms ($p = 0.048$)	174
Danhauer [35]	IG = 22 CG = 22	Restorative yoga	75 min, 1×/week,	10 weeks	SF-12 and FACT-B	Significant between-group difference for SF-12 MCS ($p = 0.004$)	IG = 9 CG = 8
Mutrie [20]	IG = 101 CG = 102	Walking, cycling, low level aerobics, muscle strengthening exercises, or circuits of specifically tailored exercises, group exercise program	45 min, 3×/week, 50–75% of HR_{max}	12 weeks	FACT-B	Significant between-group difference ($P = 0.0007$)	IG = 19 CG = 7
Rogers [21]	IG = 21 CG = 20	Based on the social cognitive theory moderate walking	> 150 min/week	12 weeks	FACT-B	Significant between-group difference for social well-being ($P = 0.03$)and overall QoL ($P < 0.001$)	IG = 1 CG = 1
Sandel [36]	IG = 19 CG = 19	Dancing	45–60 min,1-6 weeks:2×/week, 7–12 weeks:1×/week	12 weeks	FACT-B and SF-36	Significant between-group difference ($P = 0.017$)	CG = 3
Shobeiri [28]	IG = 30 CG = 30	Walking (moderate intensity)	25 min 50%HR_{max} to 45 min 75% HR_{max}, 2×/week	10 weeks	EORTC QLQ-C30 and EORTC QLQ-BR23	Significant between-group difference ($P < 0.001$)	IG = 3 CG=4[a]
Vadiraja [22]	IG = 44 CG = 44	Integrated yoga program	60 min, 3–4×/week	6 weeks	EORTCQLQ-C30	Significant between-group difference for emotional function	IG = 2 CG = 11

Table 1 (continued)

First author (year)	Sample	Intervention characteristics			Outcome		
		Exercise	Exercise session duration, frequency	Program duration	Quality of life measurements	Result	Dropout
						($p = 0.001$)and cognitive function ($p = 0.03$)	
Oh [23]	IG = 14 CG = 13	Medical Qigong program	60 min, 3–4×/week	10 weeks	FACT-B	Significant between-group difference for neuropathic symptoms ($p = 0.014$)	IG = 5 CG = 5
Adams [24]	IG = 64 CG = 70	Treadmill, cycle ergometer, or elliptical-based exercise	15 mins at 60 %VO_{2max} to 45 mins at 80% of VO_{2max}, 2×/week,	17 weeks	FACT-A	No significant between-group difference	NR
Baruth [25]	IG = 20 CG = 12	Walking	1–7 weeks:20 min, 3×/week 8–12 weeks: 30–40 min, 5×/week	12 weeks	IBCSG and SF-36	Significant between-group difference for current health and mood, physical well-being, feeling sick, appetite,effort in coping, and tiredness on IBCSG QOL, role-emotional,mental health,vitality,role-physical, general health physical functioning,mental and physical components on SF-36.	IG = 2
Ergun [37]	IG = 20 CG = 20	Brisk walking	30 min, 3×/week	12 weeks	EORTC QOL-C30	Significant improvements for functional score after the treatment	IG=2[a]
Kiecolt-Glaser [26]	IG = 100 CG = 100	Yoga	90 min, 2×/week	12 weeks	SF-36	Significant between-group difference(p = 0.01)	IG = 7 CG = 13
Chandwani [42]	IG = 53 CG = 54	Integrated yoga program	60 min, 3×/week	6 weeks	SF-36	Significant between-group difference for PCS scores (p = 0.01)	IG = 4 CG = 6
Lahart [27]	IG = 40 CG = 40	Home-based physical activity: brisk walk	1–3 months: 30 min, 3–5×/week 4–6 months: > 30 min, 5–7×/week	6 months	FACT-B	Significant but small between-group difference for FACT-B,FWB and BCS scores ($p < 0.05$ respectively)	IG = 3 CG = 7
Littman [31]	IG = 32 CG = 31	Community-based yoga	5×/week, centering Exercises (5–10 min) + seated and standing poses (50–60 min) + breathing exercises (10–15 min)	6 months	FACT-G	Significant between-group difference	IG = 5 CG = 4
Chen [29]	IG = 49 CG = 47	Chinese qigong	40 min, 5×/week	5–6 weeks	NR	Significant between-group difference for overall QOL ($P < 0.05$)	NR
Resistance							
Steindorf [30]	IG = 80 CG = 80	Progressive eight different machine-based resistance exercises	60 min, 2×/week 3 × 8–12 rep/exercise at 60%–80% of 1RM	12 weeks	EORTC QLQ-C30 and EORTC QLQ-BR23	Significant between-group difference for role function ($P = 0.035$, ES = 0.31) and pain ($P = 0.040$, ES = 0.25)	IG = 3 CG = 2
Hagstrom [41]	IG = 19 CG = 20	1–8 weeks: leg extension, leg curl or romanian deadlift, lat pull down, machine bench press, seated row, back extension, prone hold or sit ups	60 min, 3×/week, 3 × 8–10 rep/exercise	16 weeks	FACT-G	Significant between-group difference for overall QOL ($P = 0.015$) and the specific PWB subscale ($P = 0.002$)	IG=4[a] CG=1[a]

Table 1 (continued)

First author (year)	Sample	Intervention characteristics			Outcome		
		Exercise	Exercise session duration, frequency	Program duration	Quality of life measurements	Result	Dropout
		9–16 weeks: barbell squat, deadlift, free weight barbell bench press, leg press, barbell bent over row and assisted chin up					
Courneya[b] [16]	IG = 82 CG = 82	Nine different exercises: leg extension, leg curl, leg press, calf raises, chest press, seated row, triceps extension, biceps curls, and modified curl-ups	9 × 8–12 rep/exercise, at 60–70% of 1RM,3×/week,	NR	FACT-A	Significant improvement in lean body mass	IG = 6 CG = 9
Speck [40]	IG = 148 CG = 147	Strengthen abdominal and back muscles, and weight-lifting exercises	90 min, 2×/week, 3 × 10 rep/exercise	13 weeks	SF-36 and BIRS	Significantly greater improvement on BIRS total score($P < 0.0001$), Significant between-group difference for the mental summary score on SF-36	IG = 32 CG = 29
Adams [24]	IG = 66 CG = 70	Resistance exercise	2×/week, 9 × 8–12rep/exercise, 60 and 70% of 1RM	17 weeks	FACT-A	Significant between-group difference for reversing sarcopenia ($p = 0.039$) and dynapenia ($p = 0.019$),TOI-An ($p = 0.048$) and fatigue ($p = 0.008$)	NR
Ohira [39]	IG = 43 CG = 43	Nine weight-training exercises using variable resistance machines and free weights	2×/week	6 months	CARES-SF	Significant between-group difference for the physical global QOL score ($P = 0.006$)and the psychosocial global score ($P = 0.02$)	IG = 4 CG = 3
Chandwani [42]	IG = 56 CG = 54	A stepped stretching: horizontal arm stretch, breast stroke, neck stretch, quarterback throwing a football	60 min, 3×/week	6 weeks	SF-36	Significant between-group difference for PCS scores (p = 0.02)	IG = 4 CG = 6
Kilbreath [38]	IG = 81 CG = 79	Free weights and passive stretching: shoulder flexion, arm abduction, extension to pectoralis minor	45 min, 1×/week, 2 × 8–15 rep/exercise,	8 weeks	EORTC QLQ-BR23	No significant between-group difference	IG = 8 CG = 11
Combine							
Milne [46]	IG = 29 CG = 29	Aerobic: cycle and rowing ergometers, the mini-trampoline, and the step-up blocks. Resistance: chest press, chest extension, biceps curls, triceps extension, leg extension, leg curls, leg press and stretching exercise	3×/week Aerobic:25 min Resistance: 2 × 10–15 rep/exercise, stretching: 5 min	12 weeks	FACT-B	Significant between-group difference ($p < 0.05$)	IG = 1
Herrero [45]	IG = 10 CG = 10	Aerobic: running, cycling, swimming Resistance: 11 exercises engaging the major muscle groups	90 min, 3×/week, Aerobic: 80% of HR_{max} Resistance: 3 × 12–15 rep/exercise to 5 × 8–12 rep/exercise	8 weeks	EORTC QLQ-C30	Significant between-group difference for global scale($p = 0.002$) and physical function scale ($p = 0.04$)	IG = 2 CG = 2
Ariza-Garcia [43]	IG = 33/31			8 weeks	EORTC QLQ-BR23		NR

Table 1 (continued)

First author (year)	Sample	Intervention characteristics			Outcome		
		Exercise	Exercise session duration, frequency	Program duration	Quality of life measurements	Result	Dropout
	CG = 34	Swimming and strength exercise/aerobic and strength exercise	60 min, 3×/week, swimming pool (30–32 °C) + 60% of HR_{max} + 3 × 8–12 rep/exercise			Significant between-group difference for breast symptoms ($P < 0.05$)	
Do [47]	IG = 106 CG = 106	Aerobic, strengthening and core stability exercise	80 min, 5×/week, 2 × 8–12 rep/exercise to 60 and 80% of 1RM	4 weeks	EORTC QLQ-C30 and EORTC QLQ-BR23	Significant between-group difference for global health score ($p = 0.001$), physical functioning ($p = 0.013$), emotional functioning ($p = 0.001$), fatigue ($p = 0.001$), pain ($p = 0.001$), nausea ($p = 0.001$) on the EORTC QLQ-C30; arm and breast symptoms (p = 0.001) on the EORTC QLQ-BR23	IG = 74 CG = 76
Hayes [44]	IG = 67/67 CG = 60	Aerobic and strength exercise	45 min, 4×/week,	8 months	FACT-B	Significant between-group difference ($p < 0.05$)	IG=6[a]/4[a] CG=4[a]
Galiano-Castillo [48]	IG = 40 CG = 41	Resistance and aerobic exercise training, a telerehabilitation program	90 min, 3×/week	8 weeks	EORTC QOL-C30	Significant between-group difference for global health status, physical functioning (both $P < 0.001$),role functioning ($P = 0.001$),cognitive functioning and arm symptoms (both $P = 0.002$)	IG = 1 CG = 4
Ergun [37]	IG = 20 CG = 20	Upper and lower limb resistive exercise, stretching and brisk walking	75 min, 3×/week	12 weeks	EORTC QOL-C30	Significant between-group difference ($P = 0.038$).	0

CG control group, HR_{max} maximum heart rate, *IG* intervention group, *NR* not reported, rep repetition, *1RM* 1 repetition maximum,VO_{2max} maximal oxygen uptake, *CES-D* Center for Epidemiologic Depression Scale,*SF-12* 12-item Short-Form Health Survey, *SF-36* 36-item Short-Form Health Survey, *PCS* Physical Component Summary, *FACT-B* Functional Assessment of Cancer Therapy-Breast questionnaire, *FACT-G* Functional Assessment of Cancer Therapy – General, *EORTC QLQ-C30* European Organization for Research and Treatment of Cancer Quality of Life C30, *EORTC QLQ-BR23* European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Breast, *IBCSGQOL* International Breast Cancer Study Group QOL Core Questionnaire, *LYMQOL* Lymphoedema Quality of Life Tool, *BIRS* Body Image and Relationships Scale, *BCS* breast cancer subscale, *FACT-A* Functional Assessment of Cancer Therapy–Anemia scale, *CARES-SF* Cancer Rehabilitation Evaluation System Short Form, *FACIT–F* Functional Assessment of Cancer Therapy–Fatigue scale, *TOI-An* Trial Outcome Index-Anemia, *ES* Effect Size, *MCS* Mental health, *FWB* Functional well-being, *PWB* Physical well-being, *HRQOL* Health-related quality of life, *HRR* Heart rate reserve

[a] Dropouts included in analysis

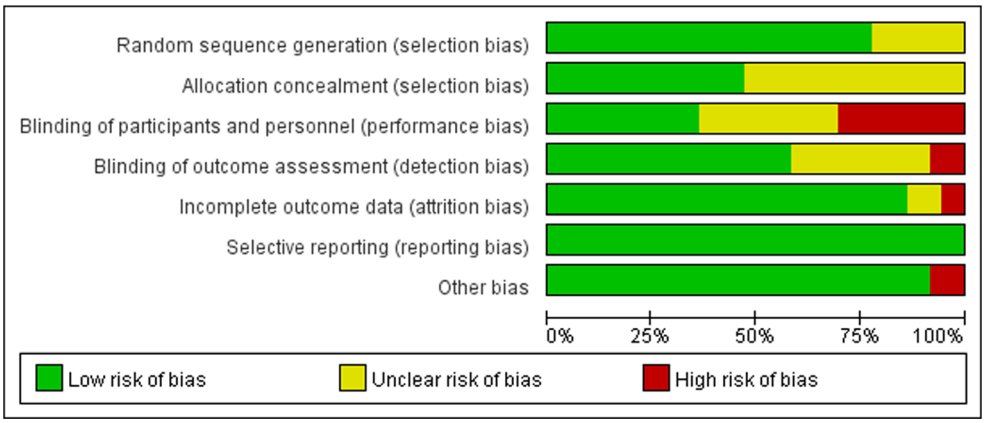

Fig. 2 Quality of included studies

Outcomes

Aerobic exercise

Twenty-five studies comprising 2327 participants examined the effect of aerobic training on QOL in patients with breast cancer [8, 13–29, 31–37, 42]. Walking was the most common aerobic training [8, 14, 17, 20, 21, 25, 27, 28, 34, 37]. Other forms of aerobic training were yoga [22, 26, 31, 32, 35, 36, 42], treadmills or bicycle ergometers [8, 16, 18, 24, 33], qi-gong [23, 29], tai chi [19], and dancing [36].

Among the 25 studies, three studies (sample sizes between 20 [18] and 175 [14]) reported no significant effects of aerobic training on QOL in patients with breast cancer compared with that of usual care [14, 18, 24]. Cadmus et al. [14] reported the effect of a home-based walking intervention on QOL among recently diagnosed breast cancer survivors undergoing adjuvant therapy and post-treatment survivors. Hornsby et al. [18] evaluated the effect of moderate-to-high-intensity aerobic training in breast cancer patients receiving neoadjuvant chemotherapy. Adams et al. [24] evaluated the effects of the treadmill, cycle ergometer, or elliptical-based aerobic exercise on sarcopenia and dynapenia in breast cancer patients.

The other 22 studies reported a significant effect of aerobic exercise on the QOL in patients with breast cancer compared with that of patients in the control group.

In the study by Basen-Engquist et al. [15], a 6-month moderate walking intervention was incorporated into daily routines and intervention was conducted in group meetings ranging from 7 to 15 participants. A positive effect was detected on the bodily pain and general health subscales of breast cancer survivors. Rogers et al. [21] evaluated the effects of a walking intervention for sedentary breast cancer survivors; participants were encouraged to convert the minutes spent in physical activity recorded on their weekly exercise logs into miles, which were graphed on a map indicating travel across the USA to the west coast. The results demonstrated significantly greater improvements in social well-being and waist-to-hip ratio in the intervention group. Shobeiri et al. [28] reported that moderate walking significantly improved global QOL in the exercise group in women suffering from breast cancer, among whom exercise intensity increased from 50 to 75%. Heart rate reserve, function (body image, sexual function), and symptoms (side effects of treatment, breast symptoms, and arm symptoms) showed a significant improvement on EORTC QLQ-BR23. Baruth et al. [25] evaluated a 12-week home-based walking intervention with telephone counseling sessions in breast cancer survivors. The walking prescription was a gradual increase in the frequency, duration, and intensity at moderate to vigorous intensity. Pedometers and physical activity logs were given to encourage self-monitoring. They found improvements in general aspects of QOL and in breast cancer-specific QOL. Ergun et al. [37] and Lahart et al. [27] reported that a moderate-intensity home-based walking intervention resulted in small significant improvements in body mass index and breast cancer-specific QOL. Participants were encouraged to achieve 150 min of moderate-vigorous physical activity over each week, followed by an in-person counseling session, telephone call, and mailed information encouraging participation in activity. Patients were taught how to measure their heart rates and maximal heart rate for their ages were calculated. Jacobsen et al. [34] and Fillion et al. [17] evaluated the effects of home-based walking on QOL in breast cancer patients receiving chemotherapy; participants were provided with a video, booklet, audio, and use of coping self-statements to manage stress. They found that the combined stress management and exercise intervention yielded effects on QOL.

Five studies evaluated yoga in people with breast cancer and found that yoga had a significant effect on QOL. Littman et al. [31] evaluated the effects of 6-month facility- and home-based yoga in overweight and obese breast cancer survivors on QOL. Participants received a yoga mat and strap, blankets, and chairs to aid with poses. Practices were designed specifically for the study. They found that yoga practice improved fatigue and decreased waist circumference; the greatest improvements were observed in women who practiced a mean of three times per week. Loudon et al. [32] reported the effect

of yoga on women with breast cancer-related lymphedema, who underwent a weekly 90-min teacher-led class and a 40-min daily session delivered by DVD. The yoga intervention reduced tissue induration of the affected upper arm and decreased the QOL sub-scale of symptoms. Danhauer et al. [35] reported that restorative yoga had significant effects for health-related QOL and fatigue for women with breast cancer who attended ≥ 7 classes/week; better intervention adherence was associated with higher self-reported physical health and health-related QOL. Kiecolt-Glaser et al. [26] and Chandwani et al. [42] reported that yoga practice substantially reduced fatigue, and resulted in increased physical functioning and physical component scale scores in women with breast cancer undergoing radiotherapy compared with the control group.

Courneya et al. [8] and Voogd et al. [33] reported the effects of exercise training on recumbent or upright cycle ergometers on cardiopulmonary function and QOL in post-menopausal breast cancer survivors. The training intensity corresponded to approximately 70–75% of maximal oxygen consumption in untrained subjects. Beneficial effects on QOL were found, with adverse events in the exercise group reported in three participants (lymphedema, gynecologic complication, and influenza). Courneya et al. [16] reported that a cycle ergometer exercise program resulted in improvements in body composition and QOL in breast cancer patients.Mutrie et al. [20] evaluated the effects of a supervised group exercise program on bicycle ergometers on QOL for women being treated for early stage breast cancer. Women were monitored to ensure that they were exercising at a moderate level (50–75% of age-adjusted maximum heart rate) and showed benefits in physical and psychological functioning at the 6-month follow-up.

Oh et al. [23] reported that a 10-week medical qigong exercise program improved QOL in women with metastatic breast cancer; the intervention included gentle stretching and body movements in standing postures, meditation, and breathing exercises. Participants were encouraged to undertake home practice every day for at least 30 min. Chen et al. [29] reported lower levels of depressive symptoms and fatigue and better overall QOL in their qigong cohort.

Mustian et al. [19] compared the efficacy of Yang-style tai chi chuan with psychosocial support therapy for health-related QOL. Participants were instructed to keep a daily log; patients undertaking tai chi chuan demonstrated significant improvements in QOL and self-esteem.

Sandel et al. [36] evaluated a 12-week dance program incorporating a variety of traditional music and movements, and reported significant improvements in QOL, shoulder range of motion, and body image scale in breast cancer survivors. The control group also showed significant improvements after crossover to active treatment in weeks 13 to 25.

Overall, these results indicate that the effect of aerobic training on QOL in patients with breast cancer is beneficial.

Resistance exercise

Eight studies comprising 1150 participants examined the effect of resistance training on QOL in patients with breast cancer [16, 24, 30, 38–42]. The studies examined resistance training with free weights, resistance training machines [38–41], and progressive stretching [16, 30, 42]. One study did not specify resistance training type [24]. Most of the training sessions were 30 min [30, 41, 42]. The most common training session frequency was two or three times a week [16, 24, 30, 39–42].

Among the eight studies, one (Kilbreath et al. [38]) reported no significant effects of resistance training on QOL in patients with breast cancer compared with that of usual care; they evaluated the shoulder muscles with progressive resistance and stretching training following surgery for early breast cancer and precipitate lymphedema.

Seven studies reported a significant effect of resistance exercise on the QOL in patients with breast cancer compared with that of patients in the control group.

Hagstrom et al. [39] reported that a 16-week supervised resistance training session had significant difference in global QOL and the specific physical wellbeing subscale in previously sedentary breast cancer survivors. Training included barbell squats, deadlifts, free weight barbell bench presses, leg presses, bent over barbell row, and assisted chin ups in one-on-one or group training sessions. Three sets of eight to 10 repetitions were performed for each exercise. They found a significant correlation between improvements in strength of the treated limb and improvements in global QOL. Speck et al. [40] showed twice-weekly strength training (included seated row, supine dumbbell presses, lateral or front raises, bicep curls and triceps pushdowns, leg presses, back extension, leg extension, and leg curl) positively impacted self-perceptions of appearance, health, mental summary scores, and social functioning for breast cancer survivors with or at risk for lymphedema, and found the intervention was beneficial regardless of prior diagnosis of lymphedema. Ohira et al. [39] and Chandwani et al. [42] evaluated the effects of weight-training exercises using variable resistance machines and free weights. They reported improved physical and psychosocial global QOL score in recent breast cancer survivors. Participants were encouraged to train with other survivors to foster friendships and found weight training-associated changes in body composition and upper body strength to improve QOL.

Steindorf et al. [30] reported that a 12-week progressive resistance training program significantly larger improved the QOL sub-scales of role function and pain. The control group carried out progressive muscle relaxation without any aerobic or muscle strengthening components. Adherence to the intervention program as well as completion rate were 97%. Adams et al. [24] reported that resistance exercise significantly

reversed sarcopenia and dynapenia in breast cancer patients and greatly improved QOL. Training was performed at 60–70% of predicted one repetition maximum. Courneya et al. [16] reported that resistance exercise improved self-esteem, QOL, and chemotherapy completion rate in breast cancer patients receiving adjuvant chemotherapy.

Overall, these results indicate that resistance training in patients with breast cancer is safe and has beneficial effect on QOL.

Combined exercise

Seven studies comprising 703 participants examined the effect of combined exercise on QOL in patients and breast cancer survivors [37, 43–48]. Combined exercise consisted of a combination of aerobic (e.g., walking, running, cycling, swimming) and resistance training (e.g., upper and lower limb resistive exercise, stretching exercise).

Milne et al. [46] evaluated a combined exercise program supervised by two exercise physiologists. The program included an aerobic component (cycle and rowing ergometers, a mini-trampoline) and resistance training consisted of different exercises (e.g., chest presses, etc.). Improvements in QOL and fatigue were detected in breast cancer survivors, and improvements in aerobic fitness were associated with improvements in QOL. Ariza-Garcia et al. [43] evaluated the effects of an 8-week combined aerobic and strength exercise program in water versus on land on QOL in breast cancer survivors. The water exercise group trained in a swimming pool with a water temperature of 30–32 °C, using pool noodles, pull buoys, and swimming board. They reported that exercise on land produced a greater increase in lean body mass, whereas water exercise was better for improving breast symptoms; both interventions improved QOL. Do et al. [47] evaluated the effects of aerobic exercises as well as stretching and strengthening exercises on QOL, cardiopulmonary function, and fatigue in breast cancer patients. Aerobic exercise was performed for 40 min at 40–75% of maximum oxygen consumption (VO_2 max), and strengthening exercises comprised two sets of 8–12 repetitions using the T-bar and gym ball at 60–80% of one repetition maximum. The intensity of exercises was set according to the guidelines for older adults, provided by the American College of Sports Medicine. They found significant differences in global health scores, physical functioning, emotional functioning, and cancer-related symptoms on EORTC QLQ-C30 and cancer-related symptoms such as arm and breast symptoms on EORTC QLQ-BR23. Hayes et al. [44] evaluated an 8-month intervention incorporating both aerobic and strength-based exercises. The multimodal exercise intervention was effective in preventing fatigue and optimizing QOL. The goals of the intervention were accumulation of 180+ min of exercise per week, remain independent exercisers, and to demonstrate that delivery of the intervention face-to-face and over-the-telephone had similar effect. Galiano-Castillo et al. [48] evaluated an Internet-based, personalized resistance and aerobic exercise program. The system could send instant messages and set up video conference sessions. QOL, pain, and muscle strength were significantly improved in breast cancer survivors. Herrero et al. [45] evaluated a combined cardiorespiratory and resistance exercise training program in breast cancer survivors and all of the subjects performed a cardiorespiratory test to measure peak VO_2 (VO_{2peak}). They found improved VO_{2peak}, QOL, and overall physical fitness. Ergun et al. [37] evaluated the effects of combined exercise on angiogenesis and apoptosis-related molecules and QOL in patients with breast cancer. Functional scores and global health scores increased significantly after the exercise program.

Overall, these results indicate that combined training in patients with breast cancer was safe and beneficial for QOL.

Discussion

The present review systematically assessed the effectiveness of aerobic exercise, resistance exercise, and combined exercise on QOL in patients with breast cancer. In this systematic review, the 36 included studies were rather heterogeneous in terms of type of intervention exercise, frequency and duration of exercise sessions, program duration, and QOL measurements. It is important to determine what types of exercise program are optimal for the improvement of QOL of breast cancer patients. Twenty-two of the 25 studies reported a significant effect of aerobic exercise on QOL in patients with breast cancer compared with that of the control group. Seven of the eight studies reported a significant effect of resistance exercise on QOL in patients with breast cancer compared with that of the control group. All seven studies reported a significant effect of combined training on the QOL in patients with breast cancer compared with that of the control group. Future research should be directed at the effects of combined exercise on QOL in patients with breast cancer.

Better intervention adherence was associated with significantly improved fatigue, physical well-being, and QOL [31, 35]. Various incentive policies were taken to reduce the drop-out rate, such as recording minutes of activity, recording steps using a pedometer, telephone meetings, group meetings, face-to-face counseling sessions, video conference sessions, and one-on-one training. Among the included studies, 24 provided supervised exercise [8, 14–21, 25–28, 31, 34, 35, 37, 39, 41–43, 45, 46, 48]. In these 24 studies, the attendance ranged from 61 to 98.4%. Rogers et al. [21] reported that participants were encouraged to convert the minutes spent in physical activity recorded on their weekly exercise logs into miles to provide participants with a feeling of accomplishment and a possible competitive opportunity, which improved the QOL.

Courneya et al. [8] reported the significant self-esteem and QOL changes in the breast cancer patients resulted from increased social interaction or a sense of accomplishment in completing the exercise program. Six studies [15–17, 25, 28, 46] reported group meetings resulted in significant improvement in vigor and a trend toward a beneficial effect on total mood disturbance, and that patients thought that the sessions with the exercise specialists were the most helpful intervention component. Two studies [44, 48] reported video conference sessions improved high acceptance and adherence to the intervention, improved QOL, and had cost advantages. Attendance exceeded 90% in three supervised exercise programs [18, 34, 39].

Among the included studies,12 discussed the intensity of exercise interventions [8, 14, 16, 18, 19, 21, 25, 27, 28, 41, 43, 44]; of these, eight studies [8, 14, 16, 18, 25, 41, 43, 44] reported that exercise prescriptions incorporating more than 150 min of high-intensity training per week was associated with a low incidence of adverse events in breast cancer patients and significantly improved upper and lower body strength and improved the QOL. Three studies [21, 27, 28] suggested that interventions should focus on achieving a weekly minimum of 150 min of moderate intensity activity, which would improve the QOL, and possibly derive associated benefits of reduced risk of mortality and recurrence [49]. One study [19] reported that less than 150 min/week of low- and moderate-intensity exercise improved QOL and self-esteem.

In the included studies, 11 reported lymphedema [15, 16, 25, 32, 36–38, 40, 41, 43, 44]. One study reported adverse events. Two of three participants who developed lymphedema had locoregional radiotherapy that included axillary irradiation, which is a strong risk factor for lymphedema. Eight studies [16, 25, 36–38, 40, 41, 43] reported neither aerobic training nor resistance training caused lymphedema or other adverse events. Ariza-Garcia et al. [43] found breast cancer survivors performing progressive exercise in water or land showed less increase in arm swelling than the control group and had improved QOL. Results supported the use of upper quadrant exercise programs. Loudon et al. [32] reported yoga reduced tissue induration of the affected upper arm and decreased symptoms having a negative effect on QOL. However, the benefits did not last on cessation of the intervention when arm volume related to lymphedema increased.

Ergun et al. [37] reported some physicians and researchers had reservations with regard to aerobic and resistive exercise, mainly due to the concerns of lymphedema. Patients restrict the use of their arms and upper body activities because of fear of developing lymphedema. However, studies showed that aerobic or resistive exercises did not induce or aggravate lymphedema in breast cancer patients [50]. Greater shoulder muscle strength is significantly associated with increased functional well-being in breast cancer patients [51]. The improvements in QOL scores were significantly correlated with changes in bench press strengthabilities but not in leg press [39]. A recent randomized study showed that self-reported physical functioning, general health, and vitality in breast cancer patients with lymphedema increased after participating in an 8-week upper extremity exercise program [52].

Conclusion

The limitations of this systematic review should be noted. Some studies do not report adverse events and there is a need to explore the adverse effects of exercise among breast cancer patients in future research. Second, some studies did not provide supervised exercise. We could not determine whether the participants completed the training program or whether they reached a moving target, which might have affected the QOL outcome. In addition, five studies did not report the specifics of the loss to follow-up and the measurement tools of studies were diverse; both can result in overestimation of the positive effects of exercise interventions in study results.

We conclude that exercise is safe and effectively improves QOL in patients with breast cancer. In particular, combined training produced a positive effect on QOL and no adverse events were reported with this multimodal intervention.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

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