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Review article

The effects of lifestyle and behavioural interventions on cancer recurrence, overall survival and quality of life in breast cancer survivors: A systematic review and network meta-analysis

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ABSTRACT

Lifestyle/behavioural interventions may improve breast cancer outcomes and quality of life (QoL); however, uncertainty remains about the most effective interventions due to limited evidence. This study aimed to assess and compare the effects of lifestyle/behavioural interventions on cancer recurrence, survival and QoL in breast cancer survivors. Electronic databases including Medline, EMBASE, PsycINFO, CINAHL and EBM Reviews were searched for relevant literature. Randomized controlled trials (RCTs) and quasi-RCTs comparing a lifestyle/behavioural intervention with a control condition in breast cancer survivors were included. Outcomes included cancer recurrence, overall survival and QoL. A network meta-analysis synthesized intervention effect. Studies not included in the analysis were reported narratively. Of 6251 identified articles, 38 studies met the selection criteria. Limited evidence exists on the impacts of lifestyle/behavioural interventions on breast cancer recurrence/survival. Exercise was identified as the most effective intervention in improving overall survival (HR 0.50, 95 % CI 0.36, 0.68). Lifestyle/behavioural interventions may improve QoL; psychosocial interventions (SMD 1.28, 95 % CI 0.80, 1.77) and aerobic-resistance exercise (SMD 0.33, 95 % CI -0.03, 0.69) were the most effective interventions to enhance QoL. This review highlights potential post-breast cancer benefits from lifestyle/behavioural interventions, notably exercise and psychosocial support for QoL and exercise for overall survival. Thus, encouraging active lifestyle, stress management and coping skills programs during and after cancer treatment may enhance physical wellbeing and QoL. However, the findings should be interpreted with caution due to the small number and sample sizes of studies. Future longer-term RCTs are required for conclusive recommendations.

1. Introduction

Breast cancer is the most prevalent malignancy and the leading cause of death from cancer among women, comprising 24.2 % of new cancer cases and 15 % of cancer deaths globally [1]. Advances in early diagnosis and treatment contribute to a 90 % 5-year relative survival rate, underscoring the importance of tailored survivorship care for women with breast cancer [2].

Beyond the risk of cancer recurrence, women with breast cancer, face increased risk of comorbidities like cardiovascular disease (CVD) and osteoporosis, impacting overall prognosis [3]. As breast cancer incidence increases at postmenopausal stage [4], the interplay of hormonal changes, aging and treatments emphasizes the need for comprehensive survivorship-focused healthcare. Even, premenopausal women may

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experience early menopause post-treatment, affecting quality of life (QoL) and survival [5,6]. Adopting a healthy lifestyle can mitigate CVD risk and non-cancer mortality in pre- and post-menopausal women [7]. Observational studies indicate the positive effects of physical activity and a high-quality diet on treatment-related adverse effects and breast cancer/non-cancer related deaths [8,9]. Although the underlying mechanism linking a healthy lifestyle to breast cancer risk or prognosis remains unclear, modulation of estrogen metabolism, inflammation and oxidative DNA damage is suggested to play a key role [10].

Breast cancer can lead to prolonged psychological distress, fatigue and impaired QoL [11]. Women often use complementary therapies like yoga, relaxation or meditation during and after cancer treatment to manage consequences of the disease and its treatments [12]. While some studies demonstrate positive impacts of lifestyle/behavioural interventions on mental wellbeing and QoL [13], most have short follow-up periods and there is a lack of evidence regarding which lifestyle/behavioural modalities are the most beneficial to recommend for sustained QoL benefits. Furthermore, limited evidence exists on the association between these interventions and breast cancer survival, highlighting the need for more comprehensive research in this area. This systematic review aimed to assess and compare the effects of different lifestyle/behavioural interventions on cancer recurrence, survival and QoL in breast cancer survivors. This review will inform clinical practice and identify remaining knowledge gaps for future research.

2. Methods

2.1. Eligibility criteria

The PICO (Population, Intervention, Comparison, Outcome) framework was used to include and exclude studies for this systematic review:

2.2. Participants

Studies recruiting breast cancer survivors who were undergoing or had completed a standard curative intent anti-cancer treatment were included. We excluded studies including women with evidence of recurrence, new/secondary primary or metastatic breast cancer (stage IV and above).

2.3. Interventions

Studies with a post-diagnosis lifestyle/behavioural intervention including healthy diets, nutritional supplements, physical activity including exercise and other activities involving body movement, weight loss interventions, mindfulness (e.g. relaxation therapy, meditation), psychoeducation and psychotherapy (e.g. cognitive behavioural therapy) were considered for inclusion in this review.

2.3.1. Comparison

We included studies comparing lifestyle/behavioural intervention to usual care/written material.

2.4. Outcome measures

Primary outcomes were cancer recurrence, disease-free survival (DFS) (time from randomization to disease recurrence or death from any cause), overall survival (OS) (time from randomization to death from any cause), breast cancer mortality and all-cause mortality.

The secondary outcome was QoL with a minimum 12-months follow-up. Studies with follow-up under 12 months were excluded to avoid transient effects, aligning with the review's focus on longer-term health outcomes post-breast cancer treatment.

2.4.1. Types of studies

We included randomized controlled trials (RCTs) and quasi-RCTs.

2.5. Search strategy

Electronic databases (Medline, EMBASE, PsycINFO, CINAHL, All EBM Reviews) were searched to identify the relevant literature. Search strategy was limited to English language and publication date of January 2000 to August 2020. We incorporated studies from 2000 onwards to establish our findings on the latest evidence on breast cancer and lifestyle interventions. This approach would offer valuable insights for current clinical practice and informed decision-making in the field. The literature search was updated in October 2021 and September 2023. Search terms are listed in Supplementary material 1. This review was performed in accordance with PRISMA guidelines and the protocol was registered in PROSPERO (CRD42021231833).

2.6. Study selection

Search results were exported into Endnote X9 and duplicates removed. Titles and abstracts were screened by four paired reviewers (LY, SW, KW, OC) independently using the systematic review management platform, Covidence (Veritas Health Innovation). Six paired reviewers (LY, SW, KW, OC, CSW, MBK) reviewed full texts articles independently and discrepancies were resolved by a third reviewer. We also searched the bibliographies of the included studies and previous systematic reviews to identify any additional studies.

2.7. Data extraction and risk of bias assessment

Five paired reviewers independently extracted data and assessed risk of bias (LY, SW, KW, MBK, CSW). Any discrepancies were resolved by a third reviewer (LY, SW, KW or CSW). Where required, the corresponding author was contacted for additional data. The quality of the studies was assessed using Joanna Briggs Institute (JBI) critical appraisal tools for each study design (quasi-experimental studies and RCTs). JBI tools assess the methodological quality of studies of various designs. Specifically, the JBI tool for RCTs address key domains such as random sequence generation, allocation concealment, blinding, statistical analysis and other potential sources of bias.

2.8. Synthesis methods

A network meta-analysis was used to pool the effect sizes and rank the efficacy of several interventions using R software program Version 3.6.1.

Pairwise meta-analyses were performed for each comparison. Evidence from both direct and indirect comparisons was averaged to calculate a network estimate. The hazard ratio was calculated using a random-effects model, which accounts for within- and between-studies variances. Treatment effects were averaged using the "netmeta" function in R software, weighted by the inverse of the total variance (sum of within and between studies variances). The "netrank" function within the "netmeta" package allowed to generate the rank of interventions from most to least beneficial using p-scores.

Standardized mean difference (SMD) with 95 % CI was used to present the effect estimate for continuous outcomes. To conduct analysis on time to event outcomes such as survival, the estimates of the log HR (SE) were extracted from studies and pooled HR with 95 % CI was calculated. HRs <1.0 and SMD >0 favour the intervention. Studies with insufficient data, adjusted values or overlapping data with other studies, were not included in the analysis. When required, we transformed the outcome data. The heterogeneity of studies was tested using I^2 statistic. Publication bias was tested by Egger's test to quantify the bias captured by funnel plot. Studies not included in the analysis were presented narratively.

3. Results

3.1. Study selection

The original search returned 5354 articles. Following screening the abstracts, 364 studies were identified for full text review. From these, 28 articles met the inclusion criteria. A total of five articles were identified from the search update and a further five studies were added from citation searching. In total, 38 articles representing 18,570 participants were included in this systematic review (Fig. 1).

3.2. Study characteristics

Of the 38 included studies, 37 were RCTs and one used a quasi-experimental design (non-RCT). Most studies were conducted in the United States ($n = 15$), with six from Canada, four from Australia, three from UK, three from France, two from Finland, two from Denmark and one each from Sweden, Spain and Germany. The sample sizes of the included studies varied from 44 to 3107. Ten authors of the included studies were contacted by email to request further data, but only two could provide us with additional information. Characteristics of the studies are presented in Table 1.

3.3. Interventions

Thirteen studies investigated exercise/physical activity effects on cancer outcomes [14–26], utilizing various modes including aerobic, resistance or combined training, with interventions ranging from home-based to supervised and lasting eight weeks to twelve months.

Four studies involved dietary interventions: Three used low-fat diets, guided by social cognitive theory and behavioural strategies [27–29]. One study [30] focused on an anti-inflammatory diet through workshops and motivational interviewing.

Nine studies examined weight loss interventions combining exercise and diet [31–39]. Twelve studies [40–51] explored mindfulness-based stress reduction (MBSR), cognitive behavioural therapy (CBT), cognitive existential group therapy (CEGT) and psychosocial interventions including stress management, problem solving and coping skills.

3.4. Study participants

Participants' mean age in most studies ($n = 31$) was 50 years or over (mean age range: 45–64 years). Six studies did not report the mean age of participants.

3.5. Risk of bias

The overall risk of bias was low in 14 studies, moderate in 23 studies and high in one study (Table 2). Most studies ($n = 30$) were at a low risk for selection bias, as a true random allocation procedure was used and the methods applied described in detail. Allocation concealment was adequately performed and reported in 14 studies. However, 24 studies were at high or unclear risk as no details were provided on allocation concealment.

Due to the nature of the interventions, blinding of participants and those delivering interventions was impossible. Therefore, all trials were at high risk of performance bias. Most studies were at high risk of detection bias due to the lack of blinding of outcome assessors. Ten studies were at high risk of attrition bias, as there was insufficient information on loss to follow-up. In most studies, participants were

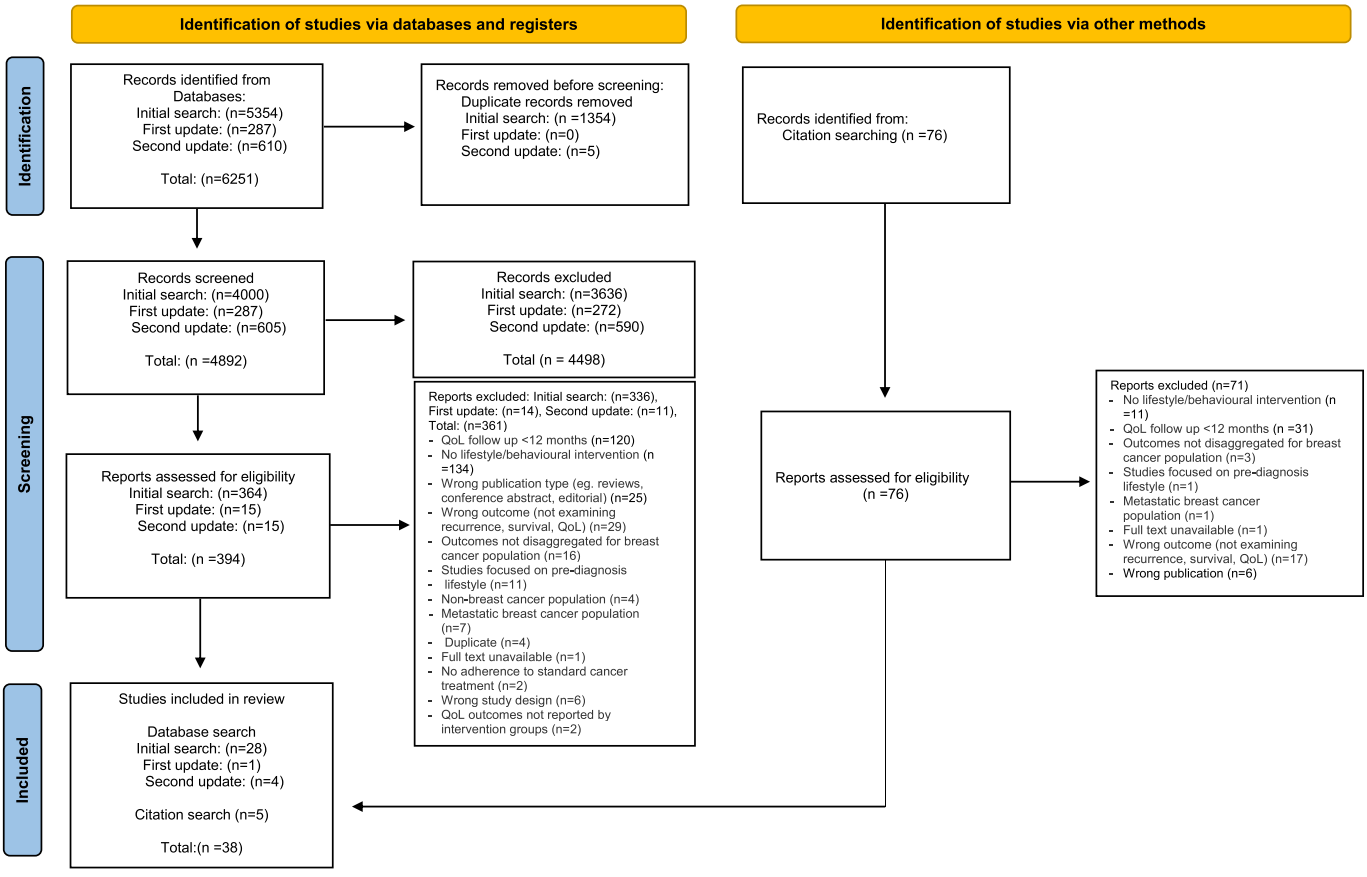

Fig. 1. Study flow diagram.
Adapted from PRISMA flowchart.

Table 1
Characteristics of included studies.

First author, year, country	Study aim	Sample size and participants age/ cancer stage	Intervention	Comparison	Relevant study outcome(s), tools and duration of follow-up	Summary of results
An, 2020, Canada [14]	To compare different types and doses of exercise performed during breast cancer chemotherapy.	STAN: n = 96 HIGH: n = 101 COMB: n = 104 Mean age (SD): 50 (8.7) years Cancer stage: I-IIIc	• STAN group:3 days/week of vigorous-intensity aerobic exercise for 25–30 min/session. • HIGH group:3 days/week of vigorous-intensity aerobic exercise for 50–60 min/session. • COMB group: 3 days/week of the same aerobic exercise as STAN group plus a resistance exercise program for 50–60 min. • Length of intervention: 12–18 weeks	–	QoL: SF-36, FACT-B Follow-up: at 6,12,24 months	No significant effects of exercise dose and type on longer-term patient-reported outcomes including QoL was observed (group-by-time interactions p = 0.53).
Andersen, 2008, USA [50]	To test the hypothesis that cancer patients coping with their recent diagnosis but receiving a psychologic intervention would have improved survival compared with patients who were only assessed.	Intervention: n = 114 Comparison: n = 113 Mean age (SD): not reported (51 % over 50 years) Cancer stage: II-III	Psychologic intervention plus assessment. • Progressive muscle relaxation for stress reduction • Problem solving for common difficulties • Identifying supportive family members/friends • Communication skills training • Strategies to increase daily activity • Improving dietary habits • Ways to cope with treatment side effects and maintain treatment adherence Length of intervention: 4 months weekly sessions followed by 8 monthly sessions.	Psychologic, behavioural, health assessment only	• Recurrence free survival • Breast cancer–specific survival • All-cause mortality Follow-up: Median of 11 years	A reduced risk of breast cancer recurrence (HR 0.55, p = 0.03) and death from breast cancer (HR 0.44, p = 0.01) were observed in the psychologic intervention arm compared with the comparison arm.
Anderson, 2012, USA [15]	To determine the effect of a moderate, tailored exercise program on health-related QoL, physical function, and arm volume in women receiving treatment for non- metastatic breast cancer.	Intervention: n = 52 Comparison: n = 52 Mean age (range): 53.6 (32–82) years Cancer stage: I-III	• Supervised exercise: 2 days/week: 5-min aerobic warm-up, 30 min of moderate to somewhat hard walking, 20 min of upper and lower body strength training and 10 min of stretching (3 months). • Home/supervised exercise 2 days/week (months 4–6). 30 min physical activity most days of the week throughout the intervention. • Home exercise or at the clinical research centre twice/week (months 7–12).	Usual care (written material)	• QoL: FACT-B Follow-up: 18 months	No significant difference was observed in mean FACT-B total scores by treatment group at 18 months (115.8 ± 1.6 for the treatment group and 114.4 ± 2.5 for the control group (p = 0.57). There were also no significant differences in the means of FACT-B subscales, adjusted for all model covariates.
Antoni, 2006, USA [40]	To assess the effects of CBSM on quality of life among women with breast cancer.	Intervention: n = 92 Comparison: n = 107 Mean age (SD): Intervention: 49.58 (9.11) years Comparison: 50.83 (8.97) years Cancer stage 0-III	• Group-based CBSM intervention focusing on anxiety reduction, cognitive restructuring, and coping skills (combines CBT and relaxation techniques in session exercise and home assignments). • The intervention used group members and leaders as role models, encouraged emotional	Educational information	• QoL: - Sickness Impact Profile - Positive States of Mind - Affects Balance Scale Follow-up: 12 months	The intervention had beneficial effects on different aspects of QoL including reduced reports of social disruption and increased emotional well-being, positive states of mind, benefit finding, positive lifestyle change, and positive affect for up to 12 months (some effects strengthened over time).

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Table 1 (*continued*)

First author, year, country	Study aim	Sample size and participants age/ cancer stage	Intervention	Comparison	Relevant study outcome(s), tools and duration of follow-up	Summary of results
			expression, replaced doubt appraisals with confidence and honed skills in anxiety reduction and skills in conflict resolution and emotional expression via assertion training. • Ten weekly 2-h sessions. Length of intervention: 10 weeks			
Antoni, 2016, USA [41]	To determine (a) whether CBSM is associated with significant attenuation in conserved transcriptional response to adversity (CTRA) gene expression relative to an active control condition, and(b) whether such attenuation in CTRA gene expression predicts longer DFS over 8–15 years of follow-up.	Intervention: n = 120 Comparison: n = 120 Mean age (SD): 49.67 (7.15) years Cancer stage: 0-IIIb	• Group-based CBSM intervention focusing on anxiety reduction, cognitive restructuring, and coping skills (combines CBT and relaxation techniques in session exercise and home assignments). • Ten weekly 2-h sessions. Length of intervention: 10 weeks	Educational information	• DFS Follow-up: 8–15 years (median 11 years)	CBSM attenuated CTRA gene expression, whereas patients randomized to control showed increased CTRA expression ($p = 0.01$). Pre-to post-intervention change in CTRA gene expression was associated with a significant increase in time to recurrence using cox proportional hazards regression (relative hazard of recurrence per standardized RNA composite unit = 4.02, 95 % CI 1.17–13.83, $p = 0.02$).
Baglia, 2019, USA [16]	To examine the effect of an exercise intervention on endocrine-related QOL and overall QOL among postmenopausal breast cancer survivors.	Intervention: n = 61 Comparison: n = 60 Mean age (SD): 61.2 (7.0) years Cancer stage: 0-III	• Twice-weekly strength-training sessions • 150 min of aerobic exercise per week (three 50-min aerobic exercise sessions or five 30-min sessions) Intervention length: 12 months	Usual care	• QoL SF-36. FACT-G, FACT-B Follow-up: 6 and 12-month	At 12 months, a combined aerobic and resistance exercise improved the overall FACT-G (8.0 versus 1.2, $p < 0.01$) and FACT-B QoL (10.2 versus 2.0; $p = 0.001$), compared with the usual care. On the SF-36 subscales, the exercise group had greater improvements in physical functioning, role functioning/ physical scores, bodily pain scores, general health perceptions, vitality scores, social role functioning, and mental functioning. The physical component scores improved significantly in the intervention group at 12 months (7.0 versus −0.8, $p < 0.0001$).
Baumann, 2017, Germany [17]	To analyse the sustainable impact of an individualized exercise program on physical activity level and fatigue syndrome on breast cancer patients in a rehabilitation centre.	Intervention: n = 111 Comparison: n = 83 Mean age (SD): Intervention: 53.8 (8.6) years Comparison: 58.2 (9.4) years Cancer stage: Non-metastatic breast cancer	• A 3-week rehabilitation program with an individual and according to their preferences and physical resource-adapted exercise program. • Two additional 1-week inpatient stays at clinic after 4 and 8 months. • A home-based exercise program was designed at the end of the rehabilitation.	• A 3-week rehabilitation program • No follow-up care	• QoL EORTC-QLQ-C30 Follow-up: 12, 18, 24 months	Both intervention and control groups showed a slight increase in overall QoL within 24 months. The data of the intervention group were higher at all time points compared to the control group but not significant.
Boesen, 2011, Denmark [51]	To test the effectiveness of a psycho-educational group intervention to improve psychological	Intervention: n = 102 Comparison: n = 103	• The intervention was based on CEGT • Two weekly 6-h sessions of psycho-education and	Usual care	• Overall survival • QoL- EORTC-QLQ-C30	There was no statistically significant effect of the intervention on the overall QoL and

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Table 1 (*continued*)

First author, year, country	Study aim	Sample size and participants age/ cancer stage	Intervention	Comparison	Relevant study outcome(s), tools and duration of follow-up	Summary of results
	distress, QoL and marital relationship in women with primary breast cancer.	Age (50–70) years: Intervention: 61 % Comparison: 66 % Cancer stage: I-IIIa	eight weekly 2-h sessions of group psychotherapy: • A lecture on healthy diets by a dietician. • Psycho-education on stress management, problem-solving, coping and cognitive reframing to examine and deal with negative thoughts, from cognitive behavioural theory. • In the 2nd part of intervention, groups of women met over 8 weeks in a cancer counselling clinic.		Follow-up: QoL: at 1, 6, 12 months Overall survival: after 4 years	the EORTC sub-scales at 6 and12 months follow-up. However, almost all psychological outcomes improved over time in patients who used anti depressive medication in both the control and intervention groups. No statistically significant effects of the intervention were found on overall survival (6 death in intervention versus 3 death in control at follow-up).
Brown, 2021, USA [39]	To test the hypothesis that exercise alone, diet alone, and the combination of exercise plus diet would improve HRQoL in survivors of breast cancer with overweight or obesity.	Intervention: Exercise: n = 87, diet: n = 87, exercise&diet: n = 87 Comparison: n = 90 Mean age (SD): 59.4 (8.7) years Cancer stage: I-III	• Exercise: included resistance and aerobic activity- Resistance exercise: twice-weekly using adjustable dumbbell weights. Aerobic exercise: moderate-intensity 4–6 days per week to a goal of 180 min weekly. • The diet group: attended 24 weekly group sessions led by a registered dietitian. Weekly nutritional counselling sessions included a weigh-in, review of the week, and behavioural modification lesson. • Diet& exercise: participants initially received six weeks of exercise instruction, followed by introduction of the diet intervention. Then they received both exercise&diet interventions concurrently.	Usual care	QoL: SF-36 Follow-up: week 52	A combination of diet& exercise led to improvements in specific health-related QoL aspects at week 52.
Carlson, 2016, Canada [46]	To compare effects of MBCR and supportive expressive group therapy (SET) over 1-year post-treatment in distressed breast cancer survivors on measures of mood, stress, social support, quality of life, spirituality and posttraumatic Growth.	Intervention: n = 134 Comparison: n = 118 Mean age (SD): MBCR: 55.12 (9.84) years SET: 54.14 (10.23) years Cancer stage: I-III	MBCR (mindfulness meditation and gentle yoga practices): • Eight weekly group sessions of 90 min • Six-hour workshop between weeks 6 and 7 for a total of 18 contact hours.	Supportive expressive therapy (SET)	• QoL: FACT-B and FACT-G Follow-up: at 6 and 12 months	There were group differences favouring MBCR on emotional (p = 0.03) and functional well-being (p = 0.02) as well as the total FACT-B score (p = 0.04), with small effect sizes. Spirituality scores on the feelings of peace (p = 0.01) and overall scores (p = 0.02) improved in the MBCR group than in the SET group, with small to medium effects that were maintained over time.
Chlebowski, 2006, USA [27]	To test the effect of a dietary intervention designed to reduce fat intake in women with resected, early-stage breast cancer receiving conventional cancer management.	Intervention: n = 975 Comparison: n = 1462 Mean age (95 % CI):	• Eight biweekly individual low-fat eating plans based on social cognitive theory • One-hour in-person counselling session • Dietician follow-up every three months.	• Usual care • Written information	• DFS • Recurrence free survival • Overall survival Median follow-up: 5 years	The HR of recurrence-free survival in the intervention group versus control was 0.71 (95 % CI 0.53–0.94). For DFS, the HR was 0.81 (95 % CI 0.65–0.99). There was no difference

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Table 1 (*continued*)

First author, year, country	Study aim	Sample size and participants age/ cancer stage	Intervention	Comparison	Relevant study outcome(s), tools and duration of follow-up	Summary of results
		Intervention: 58.6 (44.4 to 72.8) years Comparison: 58.5 (43.6 to 73.4) years Cancer stage: I-IIIa	• Optional monthly dietary group sessions.			in overall survival comparing women receiving the dietary intervention with the control group (HR = 0.89, 95 % CI 0.65–1.21). After 5 years follow-up, dietary intervention group exhibited a 24 % risk of relapse compared to control (HR = 0.76, 95 % CI 0.60–0.98)
Cornette, 2016, France [18]	To assess the effects of a home-based adapted physical activity program on aerobic capacity, strength, and fatigue in women treated with adjuvant or neoadjuvant chemotherapy for breast cancer versus usual care.	Intervention: n = 22 Comparison: n = 22 Median age: Intervention: 52 years Comparison: 49 years Cancer stage: I-IIIb	• 27-week home-based combined aerobic& resistance exercise three times per week. • Individually tailored by exercise specialist • Aerobic: at home on a cycle ergometer twice/ week or outdoor walking. • Resistance training on five muscles once/week. Each training session consisted of two sets of 8–12 repetitions.	Usual care	QoL: EORTC QOL-C30 Follow-up: 27 weeks and 54 weeks	At 54 weeks, there was no significant differences between the intervention and usual care groups or before and after intervention for EORTC QoL scores.
Courneya, 2014, Canada [19]	An exploratory follow-up of cancer outcomes from the Supervised Trial of Aerobic versus Resistance Training (START).	Intervention: n = 160 (82 resistance exercise; 78 aerobic exercise) Comparison: n = 82 Age > 50 years: 45.5 % Stage: I-IIIa	All exercise sessions were supervised by qualified exercise trainers. Warm-up and cool-down periods were 5 min of light aerobic activity and stretching. • Aerobic exercise: Three times per week on a cycle, treadmill, or elliptical ergometer beginning at 60 % of their VO_2max for weeks 1–6 and progressing to 70 % during weeks 7–12 and 80 % beyond week 12. Exercise began at 15 min for weeks 1–3 and increased by 5 min every 3 week until 45 min at week 18. • Resistance exercise: three times per week performing two sets of 8–12 repetitions of nine different exercises at 60–70 % of exercises estimated 1-repetition maximum.	Usual care	• DFS • Overall survival • Recurrence free survival Median follow-up: 89 months	DFS events were 15.6 % in the exercise group versus 22.0 % in the comparison group (HR 0.68, 95 % CI 0.37–1.24, p = 0.21). There were 13 deaths (8.1 %) in the exercise groups and 11 (13.4 %) in the control group (HR 0.60, 95 % CI, 0.27–1.33, p = 0.21). The incidence of recurrence free interval was 12.5 % in the exercise group versus 20.7 % in the control group (HR, 0.58; 95 % CI, 0.30–1.11, p = 0.09).
Darga, 2007, USA [31]	To investigate whether QoL assessed before weight loss intervention predicts weight loss and, in turn, what the effect of weight loss is on QOL measures after 12 months in early-stage breast cancer survivors.	Total sample: n = 48 Intervention: NR Comparison: NR Mean age (SD): 52.1 (8.5) years Cancer stage: I-II	Group 1. Weight Watchers only Group 2. One-on-one dietary counselling Group 3. Weight watchers and individual dietary counselling • Individualized counselling included dietary advice to decrease total energy intake and avoid high fat foods plus moderate exercise 30–45 min/day.	National cancer institute's "Action Guide to Healthy Eating" and "Food Guide Pyramid" pamphlets.	QoL- FACT-Anemia (FACTAn), FACT-G Follow-up: at 12 months	Increased weight loss at 12 months was significantly associated with higher overall QoL and physical, functional, anemia and fatigue subscales (p < 0.05).

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Table 1 (*continued*)

First author, year, country	Study aim	Sample size and participants age/ cancer stage	Intervention	Comparison	Relevant study outcome(s), tools and duration of follow-up	Summary of results
			• Counselling was performed by telephone, weekly for 3 months, biweekly during months 3–6, and monthly thereafter.			
Demark-Wahnefried, 2015, USA [32]	To examine the changes in vitality and physical functioning by arm assignment.	Intervention: n = 344 Comparison: n = 348 Mean (SEM) age: 56.2 (9.50) years Cancer stage: I-III	• Written materials and counselling to reduce weight and adhere to dietary and physical activity guidelines. • An intensive program to achieve goals: four months of weekly one-hour group sessions tapering to fortnightly for 2 months and then monthly from 6 months to 1 year. • Telephone counselling • Individually tailored newsletters quarterly basis from 6 to 24 months based on current information about physical activity, dietary intake, weight, and overcoming barriers to regulating energy balance.	Written materials and counselling to reduce weight and adhere to dietary and physical activity guidelines	QoL: SF-36 Follow-up: at 6, 12, 24 months	While vitality improved in both arms from baseline to 6 months, greater changes were observed in the intervention arm (−2.72, 95 % CI: −5.45-0.01, p = 0.05). However, these differences were not significant at other time points. Physical function score remained stable at 6 & 12 months in the intervention arm, while it was declined in the comparison arm. These differences were statistically significant at 6 months (p = 0.01) and of borderline significance at 12 months (p = 0.05), and then differences reduced over time (at 24 months, p = 0.62).
Garcia-Soidan, 2020, Spain [20]	To evaluate the effect of a two-year physical activity intervention on the self-perceived quality of life and physical functionality of female breast cancer survivors.	Strength training: n = 79 Aqua fitness: n = 79 Aerobic exercise: n = 79 Comparison: n = 79 Mean age (SD): 63 (7) years Cancer stage: Non-metastatic breast cancer	Strength group: • 10 min warm-up (mobility exercise & stretching), 30–40 min horizontal training with gym machines (Circuit of 8 exercises), 2 sets of 12 repetitions with loads of 50–60 % max resistance (MR), 10 min stretching of muscles at the end. • At week 7, the strength program at 60 % of MR, repetitions were increased to 20, participants completed circuits of 3 series between 60 % and 80 % of the MR during the last four weeks. Aqua group (two weeks low intensity, progressively increased at weeks 3–12): • 5 min warm-up, 25 min aerobic and choreographed exercises, 10 min strength/resistance work, 10 min games and 5 min stretches. Aerobic group: • 10 min warm-up,40 min choreographed aerobic exercises and some strengthening exercises without loads, 5 min stretches at the end.	Usual care	QoL: SF-12 Follow-up: 24 months	In the strength program, all of the items of the SF-12 were significantly improved (p < 0.05), except vitality which achieved a significant reduction. The aqua fitness program obtained significant improvements in physical functioning and limitations, pain and emotional limitations, general health, vitality, social functioning and the physical and mental components of the SF-12 (p < 0.01). The participants in the aerobic program showed improvements in emotional limitations (p < 0.001), however, a progressive worsening of vitality and mental Health was observed (p < 0.01).

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Table 1 (*continued*)

First author, year, country	Study aim	Sample size and participants age/ cancer stage	Intervention	Comparison	Relevant study outcome(s), tools and duration of follow-up	Summary of results
Gold, 2009, USA [28]	To determine whether a low-fat diet high in vegetables, fruit, and fiber differentially affects prognosis in breast cancer survivors with hot flashes (HF) or without HF after treatment.	HF positive: Intervention n = 1029 Comparison n = 1038 HF negative: Intervention n = 447 Comparison n = 453 Mean age: 53.6 years Cancer stage: I-IIIa (95 % I or II)	• A low-fat diet intervention based on social cognitive theory • Promoting daily dietary intake of five vegetable servings, an additional 16 oz. of vegetable juice, three fruit servings, 30 g of fiber and 15 % to 20 % of energy from fat.	Written materials based on dietary guideline	• DFS • All-cause mortality • Follow-up: Average of 7.3 years	Adjusting for tumor characteristics and antiestrogen treatment, among the HF-negative women, those who assigned to the intervention had 31 % fewer additional breast cancer events than women assigned to the comparison group (HR 0.69; 95 % CI 0.51–0.93, p = 0.02). Deaths from any cause was also significantly different between groups (intervention 9.4 %, comparison 14.1 %, p = 0.03). In women with baseline HFs, intervention did not affect additional breast cancer events (intervention, 16.5 %, comparison, 13.8 %, p = 0.10) or all-cause mortality (intervention 10.3 %, comparison 8.6 %, p = 0.20).
Goodwin, 2014, Canada [33]	To test a telephone-based weight loss intervention in postmenopausal patients with breast cancer receiving letrozole.	Intervention: n = 171 Comparison: n = 167 Mean age (SD): Intervention: 61.6 (6.7) years Comparison: 60.4 (7.8) years Cancer stage: I-III	Individual lifestyle intervention: Two-year telephone-based intervention to reduce weight: • Caloric reduction-500 to 1000 kcal daily deficit with initial recommended daily intake of 1250, 1500, or 1750 kcal • Fat reduction to 20 % of calories • Increased intake of fruits, vegetables, and grains • Moderate-intensity aerobic physical activity, gradual increase to 150 to 200 min per week • Behavioural change-motivation, relapse prevention, reducing emotional distress, time management, and overcoming barriers.	General health information from public sources	• QoL: SF-36, EORTC QLQ-C30 • Follow-up: 24 months	There was a significant improvement in SF-36 physical component scores in the lifestyle intervention arm versus the comparison arm; the mean change in physical component arm in the intervention arm was significantly higher across time points (p = 0.005). Mental component scores were with little change over time and no difference (p = 0.91) between arms. The EORTC QLQ-C30 physical condition score increased (p < 0.001) in the lifestyle intervention versus the comparison arm.
Goodwin, 2020, Canada [34]	To examine the impact of a weight loss intervention with educational materials versus educational materials alone, on BC outcomes	Intervention: n = 171 Comparison: n = 167 Mean age (SD): Intervention: 61.6 (6.7) years Comparison: 60.4 (7.8) years Cancer stage: I-III	• As described in Goodwin et al., 2014 study	General health information from public sources	• DFS • Overall survival • Median follow-up: 8 years	There were 12.9 % DFS events in the lifestyle intervention arm, versus 18.0 % in the comparison arm (HR 0.71, 95 % CI 0.41–1.24, p = 0.23). Nine patients in the lifestyle intervention arm (5.3 %) and 10 patients in the education only arm (6.0 %) died during follow-up (HR 0.86, 95 % CI 0.35–2.14, p = 0.74).
Haines, 2010, Australia [21]	To evaluate the efficacy and economic efficiency of a multimedia, multimodal physical activity program for	Intervention: n = 46 Comparison: n = 43	Home-based strength, balance, shoulder mobility and cardiovascular endurance program:	Sham flexibility Educational materials	QoL: EQ-5D instrument with visual analogue scale (VAS), EORTC C30	At 3 months assessment, a significant improvement was observed in EQ-5D VAS (p = 0.006) and EORTC

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Table 1 (*continued*)

First author, year, country	Study aim	Sample size and participants age/ cancer stage	Intervention	Comparison	Relevant study outcome(s), tools and duration of follow-up	Summary of results
	women undergoing adjuvant therapy following surgery for breast cancer.	Mean age (SD): Intervention: 55.9 (10.5) years Comparison: 54.2 (11.5) years Stage: non-metastatic breast cancer	• Educational material (workbook, DVD) • Warm-up • Balance/strength/ shoulder mobility program (varied between 5 and 15 repetitions, 1–2 sets) including lunges, bicep curls, wall push-ups, standing hip abduction, seated rows with resistance tubing, sit to stand with emphasis on eccentric control of stand to sit, overhead press, heel raises, shoulder mobility/rolling orange in large circles on kitchen tables, four quadrant step tests. • Endurance program: 20 min walking		Follow-up: 3, 6, 12 months	C30 sub-scales; global health ($p = 0.005$) and physical function ($p = 0.02$), in intervention group versus the comparison group. The 6-month assessment showed significant improvement in EORTC C30 global health ($p = 0.03$) in intervention compared to the comparison group. However, there was no significant differences between groups at 12 months for the EQ-5D VAS.
Hayes, 2018, Australia [22]	To evaluate an 8-month pragmatic exercise intervention following breast cancer on overall survival and disease free survival.	Intervention: n = 207 Comparison: n = 130 Mean age (SD): Interventions: 51.7 ± 8.8 years Comparison: 53.9 ± 8.3 years Cancer stage: 0-III	• 180 + min of moderate-intensity aerobic and resistance exercise (at least 4 days per week) in person or via telephone. • 16 scheduled sessions with an exercise physiologist	Usual care	• DFS • Overall survival Median follow-up: 8.5 years	There were 11 (5.3 %) deaths in the exercise group compared with 15 (11.5 %) deaths in the usual care group (overall survival HR 0.45, 95 % CI 0.20–0.96, $p = 0.04$). DFS events for the exercise group was 25 (12.1 %) versus 23 (17.7 %) in the usual care (HR: 0.66, 95 % CI 0.38–1.17, $p = 0.16$).
Henderson, 2012, UK [47]	To determine the effectiveness of a mindfulness-based stress reduction (MBSR) program on QOL and psychosocial outcomes in women with early-stage breast cancer, using a three-arm RCT.	Intervention: MBSR: n = 53, NEP: n = 52 Comparison: n = 58 Mean age (SD): 49.8 (8.4) years Cancer stage: I-II	MBSR: Includes CBT, group support, experiential focus, and a strong educational orientation. • Eight sessions of MBSR (seven 2.5 to 3.5-h sessions and one 7.5-h intensive silent retreat session in the 6th week • Three monthly 2-h sessions focusing on support, sharing and practice after completion of the MBSR. NEP (nutrition education program): • Education and group meal cooking focusing on dietary change and counselling.	Usual supportive care	QoL: FACT-B Follow-up: 4, 12, 24 months	At 4 months, MBSR group experienced a significant improvement from baseline in QOL outcome (spirituality subscale of the FACT-B) compared to the NEP, UC, or both. At 12 months, results showed significant differences in spirituality outcome between MBSR and NEP groups ($p \leq 0.05$). However, at 24 months, the differences were attenuated and no longer significant.
Kirkegaard, 2023, Denmark [48]	To investigate whether a psychosocial group intervention improved long-term survival in women with early-stage breast cancer and investigate differences in baseline characteristics and survival between study participants and nonparticipants.	Intervention: n = 99 Comparison: n = 102 Mean age (SD): NR Cancer stage: I-IIIA	• Two six-hour psycho-education sessions including lectures about treatment, social rights, diets, strategies from Cognitive Behavioral Therapy, sexual problems, and physical training • Eight weekly sessions of group psychotherapy to share cancer stories	Usual care	Overall survival	No significant difference was observed in survival between the intervention and control groups (HR, 0.68; 95 % CI, 0.41–1.14). Long term survival was not improved after cognitive-existential group therapy.
Kissane, 2004, Australia [42]	To investigate the impact of cognitive-existential group therapy on survival in women with early-stage breast cancer	Intervention: n = 154 Comparison: n = 149	• Three relaxation classes • Twenty weekly sessions of CEGT lasting 90 min. • The therapy was manualized and had the	Usual care plus three relaxation classes	Overall survival Follow-up: 5 years	The median survival time was 81.9 months (95 % CI 64.8–99.0 months) in the intervention versus 85.5

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First author, year, country	Study aim	Sample size and participants age/ cancer stage	Intervention	Comparison	Relevant study outcome(s), tools and duration of follow-up	Summary of results
		Mean age (SD): • Total: 46.3 (8.2) years • Intervention: 45.4 (8) years • Comparison: 47.3 (8.3) years Cancer stage: I-II	six goals of promoting a supportive environment, facilitating grief, reframing negative thinking, enhancing coping and problem solving, fostering hope, and setting priorities for the future.			months (95 % CI 67.5–103.6 months) in the control arm (HR for death,1.35, 95 % CI 0.76–2.39, p = 0.31). No significant effect of CEGT on survival was identified (HR 1.37, 95 % CI 0.73–2.32, p = 0.37).
Kwiatkowski, 2013, France [35]	To determine if the physical activity program improves long term QoL.	Intervention: n = 117 Comparison: n = 115 Mean age (SD): • Intervention: 51.8 (8.7) years • Comparison: 52.3 (10.1) years Cancer stage: Invasive non-metastatic BC	Two-week group physical and educational intervention in hydro thermal centres: • Daily physical activity for 2 h: • Endurance activity: Walking over a flat ground or pedal on a cycloergometer. • Physical exercises for both strength training and flexibility/stretching • Aqua gymnastics. • Half an hour/day bath, shower and massage (SPA care). • Aesthetic care • Dietary meals with adapted menus at the thermal centre, and dietary education. Caloric Intake restriction to 1700–2000 cal/day and daily dietary education including cooking lessons. • Personal consultations with a dietician every 6 months until 3 years.	Personal consultations with a dietician every 6 months until 3 years.	QoL: SF-36 Follow-up: 36 months	Mean QoL scores were improved in the intervention arm by 4.6 points (p = 0.03) after 1 year, then 5.4 (p = 0.02) and 6.2 (p = 0.02) respectively at 18 and 24 months. At 1 year, all differences between groups disappeared except vitality (p = 0.028). General health was close to significance (p = 0.05) as well as the aggregated 'physical health' score (p = 0.07).
Kwiatkowski, 2017, France [36]	To assess the impact of a 2-week physical/ nutritional intervention on QoL 1-year post-intervention, with follow-up over 5 years.	Intervention: n = 117 Comparison: n = 115 Mean age (SD): • Intervention: 51.8 (8.7) years • Comparison: 52.3 (10.1) years Cancer stage: Invasive non-metastatic breast cancer	As described in Kwiatkowski et al., 2013 study.	As described in Kwiatkowski et al. [35] study.	QoL: SF-36 Follow-up: 60 months	Improvement in breast cancer survivors' QoL was persistent in the intervention group at long-term follow-up. Effect-size at 2, 3, 4 and 5 years equalled respectively 0.27 (_0.01; 0.56), 0.28 (_0.02; 0.58), 0.41 (0.02; 0.81) and 0.45 (0.11; 0.80).
Long Parma, 2022, USA [30]	To assess the effects of an anti-inflammatory dietary intervention on QOL in BCS.	Intervention: n = 76 Comparison: n = 77 Mean age (SD): 56 (SD: NR) Cancer stage: 0-III	Six monthly workshops including culinary demonstrations, recipes, and meal planning, and 12 monthly motivational interviewing telephone calls.	Written material (Nutrition information)	QoL: FACT-G and FACT-B Follow-up: 12 months	There were no differences between groups on any of the QOL outcomes
Mijwel, 2019, Sweden [23]	To examine the effects of two exercise interventions on self-reported health-related and objectively measured physiological outcomes 12 months following commencement of chemotherapy.	RT-HIIT: n = 74 AT-HIIT: n = 72 Comparison (UC): n = 60 Mean age (SD): (RT-HIIT): 52.7 (10.3) years (AT-HIIT): 54.4 (10.3) years	• Intervention: Twice weekly supervised exercise sessions for 16 weeks and each session took approximately 60 min. • RT-HIIT: High-load resistance exercises including two to three sets of 8–12 repetitions at an initial	Written information about exercise according to the American College of Sports Medicine guidelines.	QoL: EORTC-QLQ-C30 Follow-up: 12 months	One year after commencement of the exercise, the AT-HIIT group showed significant improvement in QoL; role (p = 0.03, ES: 0.33) and emotional functioning (p = 0.03, ES:0.40) compared to the comparison group.

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First author, year, country	Study aim	Sample size and participants age/ cancer stage	Intervention	Comparison	Relevant study outcome(s), tools and duration of follow-up	Summary of results
		Comparison: 52.6 (10.2) years Cancer stage: I-IIIa	intensity of 70 % of their estimated one repetition maximum (1-RM), progressing to 80 % of 1-RM. The sessions concluded with 3 × 3-min in bouts of high-intensity interval exercise on a cycle ergometer interspersed with 1 min of recovery. • AT-HIIT: 20 min of moderate-intensity continuous aerobic exercise followed by the same high-intensity interval exercise as in RT-HIIT.			Also, favourable effects for fatigue were observed in AT-HIIT group versus control (p = 0.04, ES: −0.40).
Mutrie, 2012, UK [24]	To determine (a) if intervention effects continued after the 6-month follow-up (b) if women who had higher levels of activity after diagnosis and treatment had a different functional or psychological profile than women who had lower levels of activity and to elicit views from the women concerning their experience of physical activity post intervention.	Intervention: n = 101 Comparison: n = 102 Mean age (SD): Total: 51.6 (9.5) years Intervention: 51.3 (10.3) years Comparison: 51.8 (8.7) years Cancer stage: 0-III	• A 12-week supervised group exercise program plus usual care: • Two weekly classes and one additional home-based session. • Fourteen exercise classes supervised by exercise specialists in community exercise facilities including 5–10 min warm-up, 20 min of moderate level exercise and a cool-down and relaxation period; each class took 45 min. • Group discussion after the exercise for six weeks on a specific theme, guided by a model of behaviour change to improve independent exercise following the intervention. • At the end of intervention, women were guided to build an individual exercise program and invited to join a local general practice exercise referral scheme.	Usual care	QoL: FACT-G Follow-up: five years	At 5 years follow-up, there were no significant differences between groups in FACT-G QoL, although both groups showed improvements in QoL over time. Also, categorizing women by self-reported activity status, irrespective of original group allocation, showed improved QoL for those who reported being more active compared to those who were less active.
Newlands, 2019, UK [37]	To assess whether a weight loss programme comprising generic Weight Watchers referral offered to women treated for breast cancer with or without additional breast cancer-tailored dietetic support is feasible and shows promise for improving weight and QoL.	Weight watchers (WW) plus: n = 14 WW only: n = 16 Comparison: n = 15 Median age (IQR): All: 61.0 (53.5, 67.0) years WW Plus: 60.0 (53.7, 67.5) years WW referral only: 60.0 (51.0, 66.0) years Comparison: 61 (52, 70.1) years Cancer stage: Non-metastatic breast cancer	Weight Watchers plus: • Five breast cancer support group sessions led by a research dietician at cancer support centre over 14 weeks. Each session took 1–1.5 h and included presentations on various food models and informal discussions on diet & physical activity. • In week 2, Participants were given a WW referral pack which included 12 free vouchers to community meetings and digital tools. Weight Watchers only: • Participants were sent the WW referral pack including 12 free	Usual care	QoL: FACT-B, FACT-G Follow-up: 12 months	At 12 months assessment, the weight watchers group showed statistically significant improvements from baseline in physical wellbeing (p = 0.03) and the overall scale of FACT-B (p = 0.01).

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First author, year, country	Study aim	Sample size and participants age/ cancer stage	Intervention	Comparison	Relevant study outcome(s), tools and duration of follow-up	Summary of results
			vouchers to join community meetings and having access to digital content and tools.			
Penttinen, 2019, Finland [25]	To assess the effect of exercise intervention on QoL after 5 years (BReast cancer and EXercise (BREX) trial)	Intervention: n = 302 Comparison: n = 271 Mean age (SD): Intervention: 52.8 (7.2) years Comparison: 53.3 (7.7) years Cancer stage: Non-metastatic breast cancer	One year supervised and home training: Supervised training • Two different 60 min classes once a week with a rotating program (step aerobics and a circuit training). • Base on the "Rating of Perceived Exertion" (PRE) scale, the intensity of training was "somewhat hard" or "hard" (PRE: 14–16). Home-based training • Endurance training at least twice a week	Usual care	QoL: EORTC-QLQC30 Follow-up: 5 years	Participants who improved their physical activity from baseline to 5-year follow-up were more likely to improve their global health score ($p = 0.01$), physical ($p = 0.009$), social ($p = 0.01$) and role functioning ($p = 0.005$), and fatigue score ($p = 0.002$). Also, increased physical performance was significantly associated with improved global health score ($p = 0.01$), and physical ($p \leq 0.001$) and role functioning ($p = 0.001$).
Pettiford, 2017, USA [49]	To assess the impact of Bio-psychosocial Intervention (BPSI) on the QoL of breast cancer survivors.	Intervention: n = 60 Comparison: n = 60 Mean age (SD): Intervention: 59.7 (12.6) years Comparison: 60.0 (11.2) years Cancer stage: 0-III	Bio-psychosocial intervention: • Four-hour coping skills class once a month utilizing the Change Cycle model. • A 2-day course whereby participants learn the conceptual content, resource materials, and logistics of class administration. • The class focuses on the diagnosis of breast cancer representing a major life change; the structure of the class includes a profile of each stage to gain perspective and understanding, teaching personal change skills for each stage and a strategy for movement to the next stage.	Usual care	QoL: FACT-B Follow-up: 2 years	The mean QoL change from baseline were significantly higher in the intervention group than control group at 12 months ($p < 0.0001$) and 18 months ($p = 0.0004$) follow-up. At 24 months, there were similar improvements from baseline for intervention and comparison groups; except emotional well-being with a higher mean improvement for the comparison arm. The inter-group differences remained after adjusting for confounding variables.
Pierce, 2007, USA [29]	To assess whether a major increase in vegetable, fruit, and fiber intake and a decrease in dietary fat intake reduces the risk of recurrent and new primary breast cancer and all-cause mortality among women with previously treated early stage breast cancer.	Intervention: n = 1546 Comparison: n = 1561 Mean age (SD): Intervention: 53.3 (8.9) years Comparison: 53.0 (9.0) years Cancer stage: I-IIIa	Intervention was based on social cognitive theory and included 3 phases of decreasing intensity: • Phase one focused on building self-efficacy to implement the study targets including daily intake of 5 vegetable servings plus 16 oz. of vegetable juice, 3 fruit servings, 30 g of fiber, and 15 % to 20 % of energy intake from fat. • Phase two focused on self-monitoring and dealt with barriers to adherence. • Phase three focused on retaining motivation for the study dietary pattern and preventing setbacks.	Usual care/written materials	Invasive breast cancer evet All-cause mortality Follow-up: 7.3 years	Over the mean 7.3-year follow-up, there was no beneficial effects of a low-fat diet high in vegetables, fruit and fiber on additional breast cancer events and mortality. 16.7 % women in the intervention group versus 16.9 % in the comparison group experienced an invasive breast cancer event (adjusted HR 0.96, 95 % CI 0.80–1.14, $p = 0.63$), and 10.1 % women in intervention group versus 10.3 % in comparison group died (adjusted HR 0.91, 95 % CI 0.72–1.15; $p = 0.43$).

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First author, year, country	Study aim	Sample size and participants age/ cancer stage	Intervention	Comparison	Relevant study outcome(s), tools and duration of follow-up	Summary of results
Reeves, 2021, Australia [38]	To assess the effects of the intervention on weight loss, body composition, metabolic syndrome risk, and patient-reported outcomes, including whether intervention effects were sustained 6 months after intervention completion.	Intervention: n = 79 Comparison: n = 80 Mean age (SD): Intervention: 55.9 (9.1) years Comparison: 54.9 (9.3) years Cancer stage: I-III	• 12-month, remotely delivered (22 telephone calls, mailed material, optional text messages) weight loss intervention by reducing energy intake and saturated fat increasing fruits and vegetables and limiting alcohol • Moderate to vigorous intensity aerobic activity and resistance exercise physical activity	Usual care	QoL: Patient-Reported Outcome Measurement Information System (PROMIS) Global Health Scale Follow-up: 6, 12 and 18 months	At 12-months, intervention participants had significantly greater improvements in physical quality of life (2.7 [0.7, 4.6]; p = 0.007; Cohen's effect size (d) = 0.40) than comparison group.
Saarto, 2012, Finland [26]	To investigate the effects of exercise intervention on QoL, fatigue, depression and menopausal symptoms (BReast cancer and EXercise (BREX) trial)	Intervention: n = 302 Comparison: n = 271 Mean age (range): Intervention: 52.3 (36–68) years Comparison: 52.4 (35–68) years Cancer stage; non-metastatic breast cancer	Twelve months intervention including both: Supervised training: - Group training once a week consisted of two different 60 min classes on alternate weeks (step aerobics and circuit training) included warm-up and cool-down periods. - Based on the "Rating of Perceived Exertion" (PRE) scale, the intensity of training was "somewhat hard" or "hard" (PRE: 14–16). Home training (at least twice a week): - Endurance training such as walking, Nordic walking or aerobic training, jumps and leaps. - Warm-up and cool-down exercises (marching or climbing-upstairs) before and after the home training. - Brisk endurance training (walking, cycling, swimming etc.)	Usual care	QoL: EORTC QLQ-C30 Follow-up: 12 months	The intervention had no effect on the QoL of the exercise group, however, there was a linear relationship between increased physical activity and improved QoL (p = 0.006), irrespective of the intervention.
Savard, 2005, Canada [43]	To assess the efficacy of CBT for insomnia secondary to breast cancer, in a randomized controlled group design, on measures of subjective and objective sleep, psychological functioning and QoL.	Intervention: n = 28 Comparison: n = 30 Mean age (SD): Intervention: 54.81 (7.01) years Comparison: 53.37 (7.72) years Cancer stage: I-III	CBT: - Eight weekly sessions of approximately 90 min - Administered by a master-level psychologist - Administered in a group and combined the use of stimulus control, sleep restriction, cognitive therapy, sleep hygiene, fatigue and stress management.	Wait list control	QoL: EORTC-QLQ-C30 Follow-up: 12 months	Participants in the intervention group had significantly higher global QoL at post-intervention and 12 months follow-up compared to the comparison group. Significant group-time interactions (p < 0.05) and time effects (p < 0.001) were obtained on scores of global QoL whereas no significant time effect was found in the comparison group.
Stagl, 2015a, USA [44]	To evaluate whether women who received 10 weeks of group-based CBSM 2 to 10 weeks after surgery for early-stage breast cancer would report lower depressive symptoms and better QOL at an 8- to 15-year follow-up.	Intervention: n = 120 Comparison: n = 120 Mean age (SD) (at follow-up): Intervention: 60.75 (9.21) years Comparison: 64.27 (8.48) years	10-week group-based CBSM intervention: - CBT: cognitive reframing, effective coping skills training, assertiveness training, and anger management) and - Relaxation training: progressive muscle relaxation, guided visual	One-day psychoeducational seminar receiving a condensed, educational information from the intervention.	QoL: FACT-B Follow-up: 8–15 year (median, 11 years)	Participants assigned to CBSM reported significantly higher overall QoL (d = 0.58, 95 % CI 0.52–0.65), higher physical well-being (d = 0.77, 95 % CI 0.70–0.84) and higher emotional well-being (d = 0.63, 95 % CI (0.56–0.70)) than those

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First author, year, country	Study aim	Sample size and participants age/ cancer stage	Intervention	Comparison	Relevant study outcome(s), tools and duration of follow-up	Summary of results
		Cancer stage: 0-IIIb	imagery, and diaphragmatic breathing.			assigned to the comparison group.
Stagl, 2015b, USA [45]	To determine whether women who received CBSM had reduced mortality or breast cancer recurrence at 8–15 years follow-up.	Intervention: n = 120 Comparison: n = 120 Mean age (SD) (at diagnosis): Intervention: 49.69 (8.98) years Comparison: 50.99 (9.06) years Cancer stage: 0-IIIb	10-week group-based CBSM intervention: - CBT: Cognitive reframing, stress re-appraisal, effective coping skills training, assertiveness training, anger management, optimize use of social support. - Relaxation training: Progressive muscle relaxation, guided visual imagery, diaphragmatic breathing.	One-day psychoeducational seminar receiving a condensed, educational information from the intervention.	- Breast cancer-related mortality - All-cause mortality Follow-up: 8–15 years (median, 11 years)	The CBSM group was found to have a reduced risk of all-cause mortality (HR 0.21, 95 % CI 0.05–0.93, p = 0.04). Assignment to CBSM tended to be associated with breast cancer survival over and above the effects of covariates (HR 0.25, 95 % CI 0.05–1.11, p = 0.06).

Note: AT-HIIT; aerobic training combined with high intensity interval training, CBSM; Cognitive behavioural stress management, CBT; cognitive behavioural therapy, CEGT; cognitive-existential group therapy, CI; Confidence interval, COMB; combined dose of aerobic &resistance exercise, CTRA; conserved transcriptional response to adversity, DFS; disease free survival, EORTC-QLQ-C30; European Organisation of Research and Treatment of Cancer QLQ-C30, FACT; Functional Assessment of Cancer Therapy, FACT-B (for breast cancer patients), FACT-G; FACT-General, HF; hot flashes, HIGH; higher dose of aerobic exercise, HR; hazard ratio, IQR; interquartile range, MBCR; mindfulness-based cancer recovery, MBSR; mindfulness-based stress reduction, NEP; nutrition education program, QoL; quality of life, RCT; randomized controlled trial, RT-HIIT; resistance training combined with high-intensity interval training, SD; standard deviation, SEM; standard error of mean, SET; supportive expressive therapy, SF-36; 36-item short-form health survey, STAN; standard dose of aerobic exercise.

analysed in the groups they were randomized into and intention to treat analysis were reported in detail. In most studies, outcomes were measured in a reliable way and in the same way for treatment groups. Additionally, the trial design and statistical analysis were appropriate.

3.6. Primary outcomes

Eleven out of 38 included studies reported cancer recurrence/ survival.

3.6.1. Breast cancer recurrence/DFS

Nine studies with 10,135 participants explored cancer recurrence/ DFS. These outcomes were presented narratively. Conducting network meta-analysis for DFS outcome was not feasible due to the limited reporting of HRs, reporting adjusted HRs or overlapping data in the studies.

Three RCTs investigated the impact of diet on cancer recurrence. The Women's Healthy Eating and Living (WHEL) trial, involving 3107 participants, found no significant effect with a low-fat diet rich in vegetables and fruits over 7 years [29]. However, another RCT (n = 2437), reported a 24 % lower risk of recurrence with a low-fat diet after 5 years [27]. In a secondary analysis of WHEL data, the effect of a low-fat diet on breast cancer prognosis in women with and without baseline hot flushes was examined. Findings suggested fewer breast cancer events in women without hot flushes following a low-fat diet [28].

Two RCTs with 579 participants showed a non-significant reduction in breast cancer recurrence or death in the exercise group [19,22]. A weight loss intervention in 338 participants did not yield improved DFS [34]. Three RCTs explored psychological intervention [50] or cognitive-behavioural stress management (CBSM) [41,45] on DFS. A 10-week CBSM reduced leukocyte conserved transcriptional response to adversity (CTRA) gene expression, predicting longer DFS up to 15 years [41]. In another study, CBSM tended to be associated with reduced odds of breast cancer mortality and higher disease-free interval time [45]. A psychological intervention, encompassing muscle relaxation and strategies to enhance problem solving, communication and coping skills reduced risk of disease recurrence and breast cancer mortality in one trial [50].

3.6.2. Overall survival (OS)

Seven out of 11 studies reporting OS (representing 6965 participants) were included in the network meta-analysis [19,22,27,29,34,42,48].

The forest plot showed that compared to usual care, exercise was the most effective intervention in improving OS (HR 0.50, 95 % CI 0.36, 0.68) (Fig. 2.a). In terms of ranking, exercise and CEGT were the highest-ranking interventions, with the p-scores of 0.96 and 0.59, respectively (Fig. 2.a). The pooled estimate of network comparisons of interventions for OS was shown in Table 3a. The HRs (95 % CI) of exercise compared to the low-fat diet and weight loss program were 0.53 (0.37, 0.76) and 0.58 (0.22, 1.51), respectively. HR of CEGT compared to exercise was 1.56 (0.97, 2.50), (Table 3.a). I^2 in the network was 9 %.

Network plots for the most frequent comparisons were shown in Supplementary material 2a. The network meta-analysis did not show any significant effects of diet interventions on OS. However, in a secondary analysis on 2967 breast cancer survivors, a low-fat diet significantly reduced all-cause mortality among women with no baseline hot flushes, but, there was no significant diet impacts in women experiencing hot flushes [28].

Andersen et al., showed a significant lower risk of all-cause mortality in the psychological intervention arm versus control [50], albeit in a small sample size (n = 227). Also, another trial showed that the 10-week CBSM was associated with increased time to all-cause mortality [45]. However, in one RCT, no significant effect of a psychosocial group intervention [51] was observed on the OS.

3.7. Secondary outcome

3.7.1. Overall QoL and individual domains

Out of 38 included studies, 27 assessed QoL. A total of 11 RCTs (n = 2013) assessing QoL were included in the network meta-analysis, [15,16,18,21,23,24,26,30,33,37,49]. The forest plot showed that compared to usual care, psychosocial interventions (SMD 1.28, 95 % CI 0.80, 1.77) and aerobic-resistance training (SMD 0.33, 95 % CI -0.03, 0.69) were the most effective interventions in improving the overall QoL (I^2 value: 8 %) (Fig. 2.b). In terms of the ranking, psychosocial interventions, combined aerobic-resistance training and weight loss interventions were the highest-ranking interventions with the p-scores of

Table 2
Summary of risk of bias assessment.

Randomized controlled trial															
Study	Adequate randomization	Concealed allocation	Similar groups at baseline	Blinding participants	Blinding those delivering treatment	Blinding outcome assessors	Groups treated identically	Completed follow-up	Intention to treat analysis	outcomes measured in the same way for groups	Reliable outcomes measurement	Appropriate statistical analysis	Appropriate trial design	Total number of "Yes" votes (out of 13)	Total risk of bias (High 0–4, Mod 5–8, Low 9–13)
An et al. [14]	Yes	Yes	Yes	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10	Low
Andersen et al. [50]	Yes	Unclear	Yes	N/A	N/A	Unclear	Yes	No	Yes	Yes	Yes	Yes	Yes	8	Moderate
Anderson et al. [15]	Yes	Yes	Yes	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10	Low
Antoni et al. [40]	Unclear	Unclear	Yes	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	7	Moderate
Antoni et al. [41]	Yes	Unclear	Yes	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	No	Yes	Yes	8	Moderate
Baglia et al. [16]	Yes	Yes	Yes	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10	Low
Boesen et al. [51]	Yes	Yes	No	N/A	N/A	No	Unclear	Unclear	Unclear	Yes	Yes	Yes	Yes	6	Moderate
Brown et al. [39]	Unclear	Unclear	Unclear	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	7	Moderate
Carlson et al. [46]	Unclear	Unclear	No	N/A	N/A	Unclear	Yes	Unclear	Yes	Yes	N/A	Yes	Yes	5	Moderate
Chlebowski et al. [27]	Yes	Unclear	Yes	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10	Low
Cornette et al. [18]	Yes	No	Yes	N/A	N/A	No	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	8	Moderate
Courneya et al. [19]	Yes	Yes	No	N/A	N/A	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	8	Moderate
Darga et al. [31]	Unclear	Unclear	Unclear	N/A	N/A	Unclear	Unclear	Unclear	No	Yes	N/A	Yes	Yes	3	High
Demark-Wahnefried et al. [32]	Yes	Unclear	Yes	N/A	N/A	Unclear	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	8	Moderate
Garcia-Soidan et al. [20]	Yes	Yes	Unclear	N/A	N/A	Yes	Yes	No	No	Yes	Yes	Yes	Yes	8	Moderate
Gold et al. [28]	Yes	No	No	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8	Moderate
Goodwin et al. [33]	Yes	N/A	Unclear	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8	Moderate
Goodwin et al. [34]	Yes	No	Yes	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	No	Yes	Yes	8	Moderate
Haines et al. [21]	Yes	Yes	No	N/A	N/A	Yes	Yes	No	Yes	Yes	Yes	Unclear	Yes	8	Moderate
Hayes et al. [22]	Yes	Unclear	Yes	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9	Low
Henderson et al. [47]	Unclear	Unclear	No	N/A	N/A	Unclear	No	No	Yes	Yes	Yes	Yes	Yes	5	Moderate
Kirkegaard et al. [48]	Yes	Yes	No	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	8	Moderate
Kissane et al. [42]	Yes	No	Yes	N/A	N/A	Yes	Yes	Unclear	Yes	Yes	Unclear	Yes	Yes	8	Moderate
Kwiatkowski et al. [35]	Yes	Unclear	Yes	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	8	Moderate
Kwiatkowski et al. [36]	Yes	Unclear	No	N/A	N/A	Unclear	Yes	Unclear	Yes	Yes	Unclear	Unclear	Yes	5	Moderate
Mijwel et al. [23]	Yes	Yes	Yes	N/A	N/A	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10	Low
Mutrie et al. [24]	Yes	Unclear	Yes	N/A	N/A	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	9	Low
Newlands et al. [37]	Yes	No	Yes	N/A	N/A	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9	Low
Long Parma et al. [30]	Yes	Unclear	Yes	N/A	N/A	Unclear	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	8	Moderate
Penttinen et al. [25]	Yes	Yes	Yes	N/A	N/A	No	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	9	Low
Pettiford et al. [49]	Yes	No	No	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	6	Moderate
Pierce et al. [29]	Yes	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11	Low
Reeves [38]	Yes	Unclear	No	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8	Moderate
Saarto et al. [26]	Yes	Yes	Yes	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10	Low
Savard et al. [43]	Unclear	Unclear	No	N/A	N/A	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	No	6	Moderate
Stagl et al. [44]	Yes	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11	Low
Stagl et al. [45]	Unclear	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	9	Low

Quasi-experimental trial										
Study	Cause/ effect are clear	Similar participants in comparison groups	Participants in any comparisons receive similar treatment/care	Control group	Multiple measurements of the outcome pre and post the intervention	Completed follow-up	Outcomes in any comparisons measured in the same way	Outcomes measured in a reliable way	Appropriate statistical analysis	Total number of "Yes" votes (out of 9)	Total risk of bias (High 0–3, Mod 4–6, Low 7–9)
Baumann et al. [17]	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8	Low

1.00, 0.78 and 0.58, respectively (Fig. 2.b). The HRs (95 % CI) of psychosocial interventions compared to exercise (aerobic, combined aerobic-resistance and high-intensity interval training), weight loss and diet interventions were shown in Table 3.b.

Network plots for the most frequent comparisons were shown in Supplementary material 2b.

Data could not be extracted from four out of 11 studies on exercise interventions and QoL. One trial found no significant effects of exercise dose and type during breast cancer chemotherapy on QoL and psychosocial outcomes [14]. However, another trial showed that improved physical activity/performance correlated with improved global health, physical, social, role function and fatigue scores [25]. Similarly, Baumann et al. reported lower fatigue scores at 18 months in the exercise group [17]. Strength training was identified as the most effective program for improving QoL domains in comparison to aqua fitness and aerobic exercise [20].

Six trials on weight loss program and QoL were not included in the analysis, due to insufficient data. One trial revealed that greater weight loss through dietary/exercise counselling was associated with higher QoL [31]. Group physical training and dietary education in hydrothermal centres also led to significant improvements in QoL over two- and five-years follow-ups [35,36]. Additionally, overweight/obese breast cancer survivors in three studies experienced enhanced QoL domains following weight loss interventions [32,38,39].

Out of six studies on psychosocial education/mindfulness and QoL, one showed significant improvement in CBSM group 8–11 years post-intervention [44]. Another study with 157 women revealed CBSM reducing social disruption and enhancing positive states of mind and positive affect for 12 months [40]. Henderson et al., found improved spirituality at 12 months in MBSR participants [47]. Carlson et al. highlighted group differences favouring mindfulness-based cancer recovery (MBCR) in emotional and functional well-being, as well as total scores. Interestingly, women in MBCR group showed continuous improvement overtime [46]. However, one study found no effect of CBT on QoL at 12 months [43]. Also, Boesen et al. found no significant difference in psycho-education versus control, except for those who were on anti-depressant medication where all measures improved overtime [51].

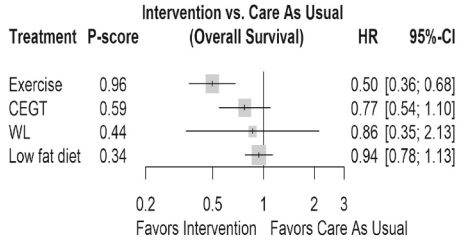
3.8. Potential bias in the review process

We presented the funnel plots for the QoL outcome and visual inspection of the plot revealed asymmetry indicating some publication bias (Supplementary material 3), although this was not supported by Egger's test ($p = 0.47$). Publication bias was not assessed for OS as there were inadequate numbers of trials to properly assess a funnel plot.

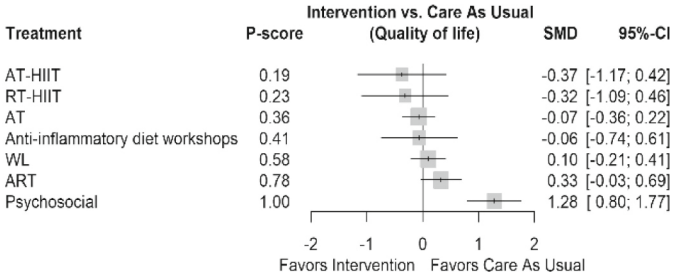
4. Discussion

To our knowledge, this is the first systematic review and network meta-analysis assessing the pooled effects of varying lifestyle/behavioural interventions on survival and QoL in breast cancer survivors. While evidence exploring the effect of these interventions on survival outcomes was scarce and inconsistent, our analysis identified exercise as the most effective intervention for improving OS. Our review also indicated that exercise, weight loss programs and mindfulness-based and cognitive behavioural stress management interventions could enhance global QoL and specific domains. Notably, combined aerobic-resistance training and psychosocial components emerged as the most efficacious interventions in the network to improve overall QoL. Despite identifying potentially beneficial lifestyle interventions post-curative intent breast cancer treatment, limited number of studies with small sample sizes poses challenges to firmly endorse specific recommendations.

Growing evidence indicates that inflammatory markers play a key role in cancer development and progression [52]. Engaging in exercise



a. Forest plot for overall survival



b. Forest plot for overall quality of life

Fig. 2. Forest plots for comparison of lifestyle interventions in the network versus usual care.
CEGT: cognitive existential group therapy, WL: weight loss program, SMD: standardized mean difference, HR: hazard ratio, ART: aerobic and resistance training, AT: aerobic training, AT-HIIT: moderate-intensity aerobic and high-intensity interval training, RT-HIIT: resistance and high-intensity interval training.

Table 3
Network meta-analysis for simultaneous comparisons of lifestyle interventions.

a. Overall survival using hazard ratio (95 % CI)

1	**CEGT**	.	.	0.77 (0.54; 1.10)	.
2	1.56 (0.97; 2.50)	**Exercise**	.	0.50 (0.36; 0.68)	.
3	0.82 (0.55; 1.23)	0.53 (0.37; 0.76)	**Low fat diet**	0.94 (0.78; 1.13)	.
4	0.77 (0.54; 1.10)	0.50 (0.36; 0.68)	0.94 (0.78; 1.13)	**Usual care**	0.86 (0.35; 2.13)
5	0.90 (0.34; 2.38)	0.58 (0.22; 1.51)	1.09 (0.43; 2.76)	0.86 (0.35; 2.13)	**WL**

b. Quality of life using SMD (95 % CI)

1	**Diet workshops**	.	.	.	.	.	.	.
2	−0.39 (−1.16; 0.38)	**ART**	.	.	.	.	0.33 (−0.03; 0.69)	.
3	0.01 (−0.73; 0.74)	0.40 (−0.06; 0.86)	**AT**	.	.	.	−0.07 (−0.36; 0.22)	.
4	0.31 (−0.73; 1.35)	0.70 (−0.17; 1.57)	0.30 (−0.54; 1.15)	**AT-HIIT**	.	−0.05 (−0.81; 0.71)	−0.38 (−1.17; 0.41)	.
5	−1.34 (−2.17; −0.51)	−0.95 (−1.56; −0.35)	−1.35 (−1.92; −0.79)	−1.66 (−2.58; −0.73)	**Psychosocial**	.	1.28 (0.80; 1.77)	.
6	0.25 (−0.77; 1.28)	0.64 (−0.21; 1.50)	0.25 (−0.58; 1.07)	−0.06 (−0.82; 0.70)	1.60 (0.68; 2.51)	**RT-HIIT**	−0.31 (−1.08; 0.47)	.
7	−0.06 (−0.74; 0.61)	0.33 (−0.03; 0.69)	−0.07 (−0.36; 0.22)	−0.37 (−1.17; 0.42)	1.28 (0.80; 1.77)	−0.32 (−1.09; 0.46)	**Usual care**	−0.10 (−0.41; 0.21)
8	−0.16 (−0.90; 0.58)	0.23 (−0.25; 0.71)	−0.17 (−0.59; 0.26)	−0.47 (−1.32; 0.38)	1.18 (0.61; 1.76)	−0.41 (−1.25; 0.42)	−0.10 (−0.41; 0.21)	**WL**

Note: CEGT: cognitive existential group therapy, WL: weight loss program, SMD: standardized mean difference, ART: aerobic and resistance training, AT: aerobic training, AT-HIIT: moderate-intensity aerobic and high-intensity interval training, RT-HIIT: resistance and high-intensity interval training.

and following anti-inflammatory diets may decrease these markers in breast cancer patients, potentially impeding recurrence and enhancing prognosis [53,54]. In a previous RCT, overweight/obese post-menopausal women experienced a reduction in inflammation biomarker levels following a caloric restriction weight loss diet and exercise [55], yet further RCTs in breast cancer survivors are required.

Meta-analysis of observational studies showed that post-diagnosis physical activity and intake of fiber, antioxidants, and multivitamins reduce recurrence and mortality risk in breast cancer survivors [8,56]. Both caloric restriction and ketogenic diets demonstrated high efficacy in cancer prevention in animal models [57]. Our review indicated exercise as the most effective intervention for improving OS; though evidence certainty is low due to the lack of sufficiently powered RCTs. The current review also found limited RCTs, with inconsistent results on dietary interventions and survival. Therefore, future interventional studies are warranted to explore the impacts of various exercise types/intensities and diets on survival.

Following cancer treatment, young breast cancer survivors often encounter early menopause, susceptibility to CVD and an elevated risk of overall mortality [5,58]. Evidence indicates that dietary interventions can enhance chemotherapy efficacy and reduce treatment toxicity and long-term side effects in cancer patients [59]. A recent meta-analysis highlights exercise benefits on cardiovascular health in post-menopausal women [60]. Consequently, it is advisable for early menopause women to adopt a healthy lifestyle to enhance their overall well-being and reduce the risk of potential complications [61].

Our network meta-analysis demonstrated that psychosocial interventions and a combined aerobic-resistance exercise were the most beneficial forms of intervention to improve QoL. However, caution is warranted in interpreting the results owing to the small number of studies assessing QoL, particularly for psychosocial outcomes, primarily relying on a single study.

Some individual studies included in this review, reported positive effects of mindfulness-based or cognitive-behavioural stress management techniques on improving QoL and certain domains [40,44,46,47]. Insufficient data on weight loss interventions for network meta-analysis were available, but individual studies suggested potential benefits for QoL [31,32,35,36,38,39]. A recent meta-analysis showed reduced BMI and improved QoL following multi-modal weight loss programs, in overweight/obese breast cancer survivors [62].

In general, despite abundant observational evidence supporting the impact of a healthy lifestyle on breast cancer outcomes [63], there is a scarcity of evidence assessing various lifestyle interventions, and many of the trials are relatively underpowered.

4.1. Strengths and limitations

The present study has several strengths and limitations. One of the key strengths of the study is the novelty of the research using a network meta-analysis to compare the effectiveness of different lifestyle interventions by combining both direct and indirect evidence. This method assists to rank interventions within the evidence network, potentially leading to informed decisions as to relative merit. In addition, most of the studies demonstrated a low to moderate risk of bias which affirm the reliability of the evidence.

Nonetheless, there are limitations to consider. The study's restriction to articles published exclusively in English, along with the omission of grey literature, may have led to some relevant data being overlooked. Also, whilst the included studies originated from a number of countries, they were largely North American, Australian and European, so generalisability of findings to culturally and ethnically diverse women with breast cancer is challenging.

The network meta-analysis faced limitations due to limited number of RCTs, most with small sample sizes. Furthermore, some outcomes were solely based on a single study, contributing to insufficient statistical power and low precision of some effect sizes. Despite low statistical heterogeneity suggesting small variation in intervention effects, clinical heterogeneity in interventions nature and participants characteristics could affect interpretation of the results.

5. Conclusions

This review highlights potential post-breast cancer benefits from lifestyle/behavioural interventions, notably exercise and psychosocial supports for QoL and exercise for OS. Thus, breast cancer women will benefit from adopting a healthy lifestyle and engaging in stress management and coping skills programs during and after cancer treatment. However, these findings should be interpreted with caution due to small number of studies assessing each outcome. Future RCTs with longer interventions and follow-up are required to provide conclusive evidence and firm lifestyle recommendations in breast cancer survivors.

Contributors

Ladan Yeganeh contributed to study conception and design, developed the protocol, ran the searches, screened search results, performed data extraction and quality assessment and drafted the manuscript.

Suzanne Willey contributed to study design, study screening, data extraction, quality assessment and manuscript preparation.

Ching Shan Wan contributed to study screening, data extraction, quality assessment and manuscript preparation.

Mahnaz Bahri Khomami contributed to study screening, data extraction and quality assessment.

Mohammad Chehrazi contributed to data analysis.

Olivia Cook contributed to study design and study screening.

Kate Webber contributed to study design, study screening, data extraction, quality assessment and manuscript preparation and provided clinical expertise.

All authors read and approved the final manuscript.

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Declaration of competing interest

The authors declare that they have no competing interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.maturitas.2024.107977.

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