



# The effectiveness of exercise and/or nutritional interventions to improve the quality of life of women with breast cancer receiving radiation therapy: a scoping review

Laura Feighan<sup>1</sup> · Lesley MacDonald-Wicks<sup>2</sup> · Robin Callister<sup>3</sup> · Yolanda Surjan<sup>1</sup>

Received: 9 January 2024 / Accepted: 7 October 2024  
© The Author(s) 2024

## Abstract

Currently, in Australia, 1 in 8 women are diagnosed with breast cancer. A common adjuvant treatment for breast cancer is radiation therapy (RT). The amalgamation of side effects caused by RT treatment can ultimately affect a patient's quality of life (QoL). With increasing breast cancer survival, a greater focus on the non-lethal consequences of this disease and its treatment is warranted. Exercise and nutrition have proven beneficial in promoting and supporting overall health and managing chronic diseases. Furthermore, exercise has demonstrated improvement and sustainment to QoL. The focus of this scoping literature review was to determine the scale of evidence regarding the effectiveness of exercise and/or nutritional interventions for women with breast cancer receiving radiation therapy. An online search of five databases was conducted to identify studies published between 2000 and 2023. The 58 studies included in the scoping review comprised 46 interventions and 4615 women with breast cancer who received radiation therapy participated. Most studies (90%;  $n=52$ ) were 'exercise only' based, 3% ( $n=2$ ) were 'nutrition only', and the remaining 7% ( $n=4$ ) of studies were combined exercise and nutrition interventions. The findings from this review highlight most studies are dedicated to investigating exercise. Further research is required to fully understand the potential benefits of these interventions and their synergistic impact on the quality of life of women with breast cancer receiving radiation therapy.

**Keywords** Breast cancer · Radiation therapy · Diet · Nutrition · Exercise · Quality of life · Survivorship

## Introduction

Breast cancer is an insidious disease that affects 1 in 8 Australian women [1]. Radiation therapy (RT) treatment for breast cancer is widely utilised as an adjuvant treatment, generally occurring post-surgery and chemotherapy. RT is employed to maintain local control and prevent recurrence. The degree of treatment is dependent on the extent of the disease, including treatment to the whole breast following breast-conserving surgery and chest wall treatment post-mastectomy, and may incorporate treatment to diseased lymph nodes [2].

While the continual advancements of RT provide precision accuracy to target volumes, it is difficult to completely spare surrounding healthy tissues and organs in the process [3]. Consequently, RT can cause side effects, which are dependent on the site of the body being treated, the radiation prescription, and the demographic characteristics of the patient (such as age and comorbidities). For breast cancer, common side effects include skin reactions, fatigue, and lymphoedema

---

✉ Yolanda Surjan  
Yolanda.Surjan@newcastle.edu.au

Laura Feighan  
Laura.Feighan@newcastle.edu.au

Lesley MacDonald-Wicks  
Lesley.Wicks@newcastle.edu.au

Robin Callister  
Robin.Callister@newcastle.edu.au

<sup>1</sup> Present Address: Global Centre for Research and Training in Radiation Oncology, School of Health Sciences, College of Health, Medicine and Wellbeing, The University of Newcastle, Callaghan, Newcastle, NSW, Australia

<sup>2</sup> School of Health Sciences, College of Health, Medicine and Wellbeing, The University of Newcastle, Callaghan, Newcastle, NSW, Australia

<sup>3</sup> School of Biomedical Sciences and Pharmacy, College of Health, Medicine and Wellbeing, The University of Newcastle, Callaghan, Newcastle, NSW, Australia

[4]. The amalgamation of such RT-associated side effects can adversely affect a patient's quality of life (QoL) [5].

QoL is a multidimensional concept that considers all characteristics impacting a person's life and well-being. The World Health Organisation defines QoL as an '*individuals' perception of their position in life in the context of culture and value systems in which they live and in relation to their goals, expectations, standards and concerns*' [6]. Health-related QoL includes information on the physical and mental health of individuals and the impact of health status on QoL [7]. Alongside physical side effects of RT, women with breast cancer can experience anxiety and depression, compromised sleep quality, mood disorders and impaired physical functioning, weight and body composition changes, stress, and self-esteem depletion [8].

Due to the continually improving medical and technological developments in breast cancer treatment, the current survival rate for the Australian population is rapidly improving, with the current relative survival rate being 92% [1]. With breast cancer survival rates rising, a greater focus on the non-lethal consequences of this disease and its treatment is essential. QoL is now deemed an important aspect when considering a patient's treatment pathway. It is recognised as a critical outcome variable separate to medical or clinical outcomes and can be included in the deliberation of a patient's prognosis [9, 10]. Furthermore, in view of the improving breast cancer survival rate, there is a growing demand to implement high-quality strategies for women in the survivorship phase. Survivorship refers to a person's well-being from cancer diagnosis to the end of life. This includes all aspects of QoL and can encompass late toxicity and lifestyle interventions [11].

Two interventions often proposed to have positive effects on QoL in multiple contexts, including cancer, are improvements to diet and exercise quality [12, 13]. Ruegsegger et al. discuss the support physical activity and exercise provide in both physical and mental health, including the connection between inactivity and the development of chronic disease (such as coronary heart disease and hypertension) and psychological disorders (such as depression and anxiety) [14]. Moreover, an exploration of the diet quality and QoL in Australians between 55 and 65 years was undertaken by Milte et al. where it was found that adherence to a healthy diet was associated with better QoL [15].

There is currently a lack of exercise and dietary guidance available for women with breast cancer receiving RT. Insufficient information exists on how exercise and nutritional advice could enhance their treatment experience and recovery. Literature has traditionally focused on diagnoses like gastrointestinal and head and neck cancer, due to the acute RT side effects patients experience (such as nausea, vomiting, and difficulty swallowing) [16, 17]. Furthermore, there is a lack of literature specifically focusing on RT treatment, with 'cancer treatment' used as an umbrella term for the various treatment options patients may undertake, despite

the vast differences in the side effects and impact on the patient's lifestyle of each treatment type [18, 19].

The primary aim of this scoping review was to identify the existing literature reporting the use of exercise and/or nutritional interventions to improve an aspect of QoL for women with breast cancer receiving radiation therapy. Secondary objectives were to summarise the characteristics of these interventions and the aspects of QoL reported. Understanding the impact of exercise and nutrition on women with breast cancer receiving RT could potentially improve their QoL, health outcomes, and RT experience.

## Methods

This literature review was conducted using the PRISMA guidelines for scoping reviews (Prisma-SCR) [20].

### Search strategy

An online search of the Medline, CINAHL, Embase, Cochrane, and SCOPUS databases was conducted between 2000 and October 2023 in conjunction with a medical librarian, using predefined keywords (for the full search strategy, see Supplementary Material).

### Eligibility criteria

The Population, Intervention, Control, Outcomes and Study Design (PICOS) framework was implemented to specify inclusion criteria (see Table 1) [21].

### Quality of life measures

As QoL is a broad term, encompassing many aspects of a person's life, the term QoL was included in the review as a general term and included various elements of QoL (such as fatigue, depression, mood states, and physical functioning). This was to ensure any variable of the six domains of QoL were reported on, making for a thorough review of QoL impact. The six domains of QoL as per the World Health Organisation include physical, psychological, level of independence, social relationships, environment, and spiritual/religion/personal beliefs [6].

### Study selection and data extraction

The online platform Covidence (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia. [www.covidence.org](http://www.covidence.org)) was used to facilitate the screening, full-text review, and data extraction process. After duplicate articles were removed, title and abstract screening was performed by two researchers, who checked for relevance. Subsequently, the same researchers independently

**Table 1** PICOS framework for inclusion/exclusion criteria

<b>Population</b>	<p><b>Included</b></p> <ol style="list-style-type: none"> <li>1. Females</li> <li>2. 18 years +</li> <li>3. Diagnosed with breast cancer</li> <li>4. Treatment included RT</li> </ol> <p><b>Excluded</b></p> <ol style="list-style-type: none"> <li>1. Males</li> <li>2. Females under 18 years</li> <li>3. Not diagnosed with breast cancer</li> <li>4. Treatment did not include RT</li> <li>5. Interventions that are not related to exercise and/or nutrition</li> </ol>
<b>Intervention</b>	<p>Only literature with exercise and/or nutrition-specific interventions will be considered for inclusion. As there is a vast range of exercise and nutrition subtypes, all will be included and categorised, enabling comparison. Examples of intervention subtypes to be included:</p> <ul style="list-style-type: none"> <li>• Exercise: aerobic/cardiovascular, resistance/strength, walking, Yoga, tai chi, Qigong, Nia, dance, stretching, Pilates</li> <li>• Nutrition: change to nutrients, food groups, diet types, dietary patterns, diet quality</li> </ul> <p>The exposure group will be those who participate in an exercise and/or nutrition intervention</p>
<b>Comparator</b>	Comparators will be those that do not participate in an exercise and/or nutrition intervention
<b>Outcome</b>	To be included in this review, studies must assess exercise and/or nutrition as intervention/s for women with breast cancer receiving RT
<b>Study design</b>	All study designs, full-text articles from the year 2000 to present, published in English, peer-reviewed journals

reviewed the full texts to identify eligible articles. Consensus of conflicts was achieved via a third researcher's review. The study details, intervention/s, outcome measures, and outcomes were extracted by two researchers independently. For all disagreements, a consensus was achieved by a third researcher.

## Results

### Study selection

In total, 3954 articles were identified from the five database searches. Following the removal of 80 duplicates, 3874 titles and abstracts were screened, and 3749 articles were excluded. Reasons for exclusion included wrong cancer diagnosis, wrong stage of treatment, wrong intervention, and/or wrong outcomes. After 116 full texts were screened, 58 studies were eligible for inclusion in the scoping review. A PRISMA flowchart of the study selection process is in Fig. 1.

### Study designs

Most studies (86%;  $n = 50$ ) (Table 2) were randomised controlled trials (RCTs) where participants were randomly assigned to either an intervention group or a control group (who received usual care). A total of 55 interventions were reported from the total 58 studies (i.e., two interventions

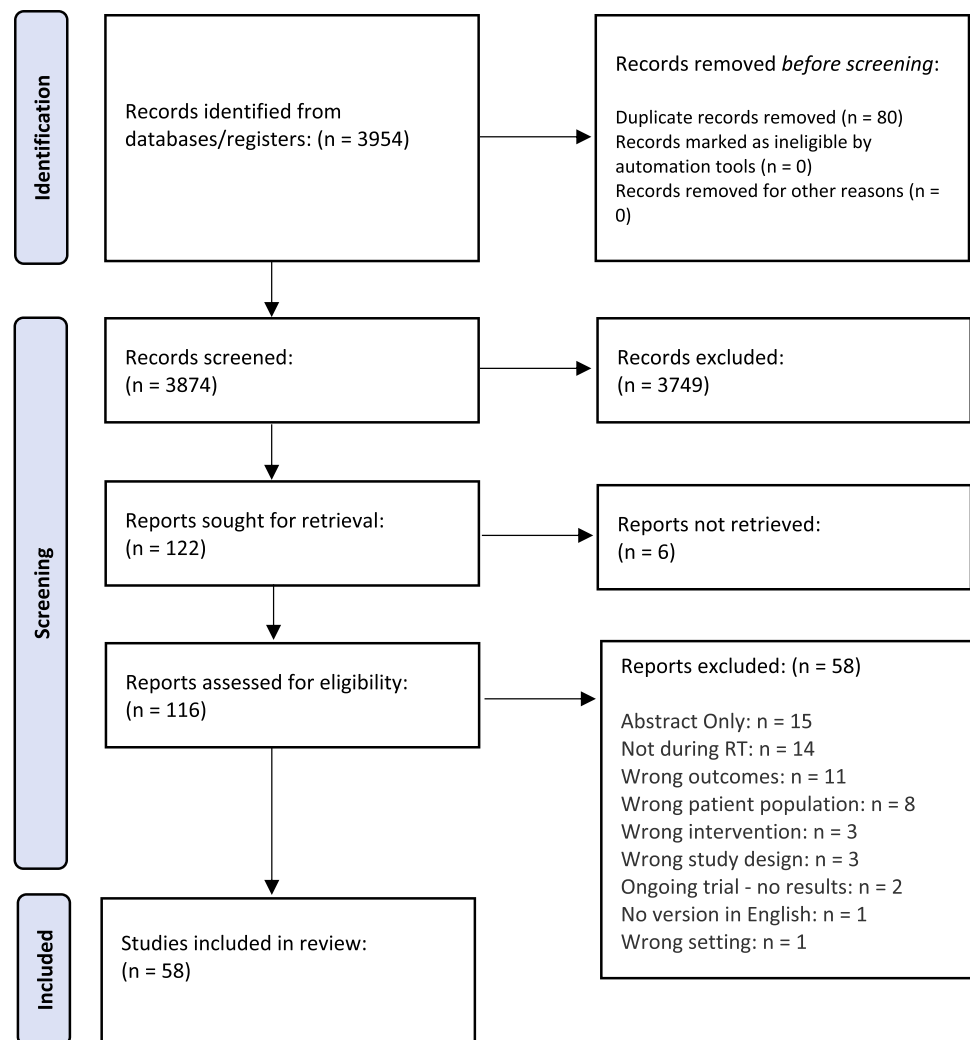
published three studies, and another intervention published two studies). The duplicate studies were included in this review due to the authors reporting on different outcome measures from the same intervention.

### Settings and geographical locations

Of the 81% ( $n = 47$ ) of studies that reported on intervention settings, 24% ( $n = 14$ ) were carried out in the hospital where the participant was receiving radiation therapy, 31% ( $n = 18$ ) were undertaken at home, and 14% ( $n = 8$ ) begun in a hospital/supervised setting before being completed at home. Other settings included clinics or study centres (10%;  $n = 6$ ) and gymnasiums or recreation centres (10%;  $n = 6$ ). Most studies were performed in the United States of America (29%;  $n = 17$ ) or Germany (15%;  $n = 9$ ).

### Participant characteristics

Collectively, a total of 5352 women with breast cancer were included, of which 4615 received radiation therapy (some studies only had a portion of participants receiving radiation therapy). Ages ranged between 18 and 78 years. Breast cancer diagnoses included in most studies (74%;  $n = 43$ ) were stage I–III; the remaining studies either included up to stage IV or did not report this information. In addition to radiation therapy, participants had surgery (79%;  $n = 46$  studies), chemotherapy (83%;  $n = 48$  studies), and/or hormone therapy (22%;  $n = 13$  studies), with 93% ( $n = 54$ ) of

**Fig. 1** Scoping review flow-chart. [20]

studies reporting participants received two or more treatment types. Only 36% ( $n=21$ ) of studies reported the radiation therapy treatment technique and/or prescription participants received, with the majority prescribed 50 Gy/25# (either three-dimensional conformal radiation therapy or intensity-modulated radiation therapy) and a boost.

### Quality of life measures

For all 58 studies, the main outcomes measured were general quality of life (57%;  $n=33$ ), fatigue (52%;  $n=30$ ), and depression (24%;  $n=14$ ). For these, 24% ( $n=14$ ) used the European Organisation of Research and Treatment of Cancer (EORTC) Core QoL Questionnaire (EORTC QLQ C-30), 28% ( $n=16$ ) used the Brief Fatigue Inventory (BFI), and 10% ( $n=6$ ) used the Centres for Epidemiological Studies Depression Measure (CES-D). Some studies measured anthropological aspects via callipers, devices (such as arm-bands), digital inclinometers, and saliva and blood samples. All outcome measures and results are reported in Table 2.

### Exercise-only studies

Of the 58 studies, most interventions (90%;  $n=52$ ) were ‘exercise-only’ (Table 2). The most common exercise interventions were aerobic/cardiovascular training with intensities ranging from low to moderate (28%;  $n=16$  of the 58 total), resistance/strength training (24%;  $n=14$ ), yoga (22%;  $n=13$ ), and walking (21%;  $n=12$ ). Less-utilised exercise interventions included stretching, dancing/dance movement, Mat Pilates, Kinesiotherapy, Qigong, and Nia exercise.

Many exercise-only interventions were implemented over 6 weeks (28%;  $n=16$ ) precisely corresponding with the participant’s radiation therapy treatment regimen/prescription. Furthermore, 47% ( $n=27$ ) of exercise-only studies interventions either continued past cessation of active RT treatment or did not specify the length of intervention (Table 2 divides studies based on intervention length). Exercise frequency ranged from 2 to 7 times per week and session duration ranged from 20 to 90 min. For 22% ( $n=13$ ) of the studies, a qualified instructor supervised the exercise sessions, 21% ( $n=12$ ) were

**Table 2** Details of scoping review studies

Author Year Country	Age Breast cancer stage	Number of participants	Measures	Assessment	Type of exercise	Exercise period	Nutrition focus	Nutrition consultation/ education timeline	Nutrition inter- vention method	Outcomes
<b>'Exercise-only' studies</b>										
<b>During active RT treatment only (period in which patient is receiving RT)</b>										
Adams-Campbell et al 2023 USA [22]	18–75 years 0A–IIIA	Total: 30 Received RT: 30	HRQoL/QoL; fatigue	FACT-B; FACIT-F	Aerobic/cardiovascular (moderate intensity)	'For the duration of RT— weeks NR, 5 sessions per week, 15 min per session 6 weeks, 2 sessions per week, 75 min per session Not clear				Improvement in QoL Reduction in fatigue
Addington et al 2018 USA [23]	> 18 years 0–III	NR	Shoulder/arm ROM	Questionnaire (self-reported); Telephone interview; Yoga instructor completed a qualitative survey	Yoga					
Banerjee et al 2007 India [24]	30–70 years II–III	Total: 68 Received RT: 68	Anxiety; depression; stress	HADS; perceived stress scale	Yoga	6 weeks, sessions per week NR, 90 min per week				Reduction in depression; anxiety; stress
da Silva Leal et al 2016 Brazil [25]	Average: 54–55 years 0–III	Total: 35 Received RT: 35	Shoulder/arm ROM; perimetry of the upper limbs	Device (armband), Physiotherapy evaluation	Kinesiotherapy of the upper limbs	5–6 weeks, 2 sessions per week, session duration NR				Improvement in ROM
Chandwani et al 2010 USA [26]	> 18 years 0–III	Total: 71 Received RT: 71	HRQoL/QoL; fatigue; sleep quality; anxiety; depression	SF-36; BFI; PSQI; CES-D; STAI; IES; BFS;	Yoga	6 weeks, 2 sessions per week, 60 min per session				Improvement in QoL No change in depression; fatigue; sleep quality; anxiety
Chandwani et al 2014 USA [27]	> 18 years 0–III	Total: 163 Received RT: 163	HRQoL/QoL; fatigue; sleep quality; depression; physical functioning; cortisol levels	SF-36; BFI; CES-D; saliva samples	Yoga	6 weeks, 3 sessions per week, 60 min per session				Improvement in QoL; physical functioning; general health Reduction in fatigue Steeper cortisol slope in yoga group No change in sleep quality

Table 2 (continued)

Author Year Country	Age Breast cancer stage	Number of stage participants	Measures	Assessment	Type of exercise	Exercise period	Nutrition focus	Nutrition consultation/ education timeline	Nutrition inter- vention method	Outcomes
Chen et al 2013 China [28]	> 18 years 0–III	Total: 100 Received RT: 100	HRQoL/QoL; fatigue; sleep quality; depres- sion; cortisol rhythm	FACT-G; CES-D; BFI; PSQI; saliva samples	Qigong exercise	5–6 weeks, 5 sessions per week, 40 min per session				Improvement in QoL Reduction in fatigue; depression Improvement in physical functioning; mood state (depression- dejection; anger-hostil- ity) Reduction in fatigue No change in mood state (tension-anxi- ety; vigour- activity; fatigue-inertia; confusion- bewilderment)
Drouin et al 2005 USA [29]	20–65 years 0–III	Total: 21 Received RT: 21	Fatigue; mood state; physical function- ing	R-PFS; POMS	Walking; indi- vidual exercise prescriptions	6–7 weeks, 3–5 sessions per week, 20–45 min per session				
Ho et al 2016 China [30]	> 18 years 0–III	Total: 139 Received RT: 139	HRQoL/QoL; fatigue; sleep quality; anxiety; depression; stress; pain	HADS; perceived stress scale; FACT-B; BFI; Brief Pain Inventory; PSQI	Dance move- ment therapy	3 weeks, 2 sessions per week, 90 min per session				Improvement in QoL; sleep quality Reduction in fatigue; stress; pain No change in depression; anxiety
Hwang et al 2008 Korea [31]	30–70 years NR	Total: 37 Received RT: 37	HRQoL/QoL; fatigue; shoulder/ arm ROM; pain	WHOQOL- BREF; BFI; physiotherapy evaluation	Aerobic/car- diovascular (intensity not reported); resistance/ strength train- ing; stretching	5 weeks; 3 sessions per week, 50 min per session				Improvement in QoL; ROM Reduction in fatigue; pain

Table 2 (continued)

Author Year Country	Age Breast cancer stage	Number of participants	Measures	Assessment	Type of exercise	Exercise period	Nutrition focus	Nutrition consultation/education timeline	Nutrition intervention method	Outcomes
Ho et al 2016 China [32]	> 18 years 0–IV	Total: 104 Received RT: 104	HRQoL/QoL; Self-esteem; mood state; physical functioning; physical symptoms; disease and treatment coping	Questionnaire (self-reported)	Dance	3 weeks, 6 sessions per week, 90 min per session				Improvement in QoL; physical symptoms; mood state; self-esteem
Ho et al 2018 China [33]	Mean: 49.4 years 0–III	Total: 121 Received RT: 121	Fatigue; sleep quality; cortisol levels; pain	Perceived stress scale; BFI; Brief Pain Inventory; PSQI; saliva samples	Dance movement therapy	3 weeks, 2 sessions per week, 90 min per session				Improvement in sleep quality Reduction in fatigue; stress Steeper cortisol slope in dance movement therapy group Improvement in QoL Reduction in fatigue
Kulkarni et al 2013 [34]	30–60 years I–II	Total: 54 Received RT: 54	HRQoL/QoL; fatigue	BFI; WHOQOL-BREF	Walking; aerobic/cardiovascular (intensity not reported); stretching	6 weeks; 5 sessions per week; 30–50 min per session				Improvement in ROM; scar tissue No change in arm circumference; functional capacity of shoulder
Oliveira et al 2009 Brazil [35]	52.7 ± 10.2 years (study), 48.0 ± 10.1 years (control) 0–IV	Total: 69 Received RT: 69	Shoulder/arm ROM; arm circumference; scar tissue formation (adhesion); functional capacity of shoulder	Goniometer; physical therapy protocol; Win-gate Scale	Physical therapy—kinesiotherapy	5–6 weeks, 3 sessions per week, 45 min per session				Improvement in QoL; physical functioning Reduction in fatigue; stress;
Mock et al 2001 USA [36]	28–75 years IA–IIIA	Total: 50 Received RT: 31	HRQoL/QoL; fatigue; distress; mood state; physical functioning; social functioning	PFS; POMS; MOS-Emotional; MOS-Social; MOS SF-36; MOS-Physical; Walk Test and Activity Level Rating Scale	Walking	6 weeks (during RT or 6 months (during CT), 5–6 sessions per week, 15–30 min per session				Improvement in QoL; physical functioning Reduction in fatigue; stress;

Table 2 (continued)

Author Year Country	Age Breast cancer stage	Number of stage participants	Measures	Assessment	Type of exercise	Exercise period	Nutrition focus	Nutrition consultation/ education timeline	Nutrition inter- vention method	Outcomes
Mock et al 2005 USA [37]	18–70 years 0–III	Total: 119 Received RT: 69	Fatigue; Physical functioning	PFS; MOS SF-36	Walking	6 weeks (dur- ing RT) or 3–6 months (during CT), 5–6 sessions per week, 15–30 min per session				Reduction in fatigue
Pickett et al 2002 USA [38]	34–75 years IA–IIIA	Total: 52 Received RT: 33	Fatigue	Investigator- developed diary recorded fatigue level ratings	Walking	6 weeks, 5–6 sessions per week, Started at 10–15 min— advanced to 30 min per session				Not clear
Raghavendra et al 2009 India [39]	30–70 years II–III	Total: 88 Received RT: 88	Anxiety; depres- sion; stress; cortisol levels	Saliva sam- ple; HADS; perceived stress scale	Yoga	6 weeks, 3 sessions per week, 60 min per session				Reduction in anxiety; depression; stress; cortisol levels
Torres et al 2023 Brazil [40]	> 18 years 0–III	Total: 156 Received RT: 156	Fatigue	FACIT-F	Mat Pilates	3–6 weeks (alongside RT), 2 sessions per week, 60 min per session				Reduction in pain No change in fatigue
Vadrajaja et al 2009 India [41]	30–70 years I–III	Total: 88 Received RT: 88	HRQoL/QoL	EORTC QLQ C-30; PANAS	Yoga	6 weeks, minimum 3 sessions per week, 60 min per session				Improvement in QoL
VanderWalde et al 2021 USA [42]	> 65 years 0–III	Total: 54 Received RT: 54	Fatigue; physical functioning	FSI, PROMIS, SPPB	Walking	4–6 weeks (alongside RT), 3–5 sessions per week, 10–30 min per session				Reduction in fatigue



Table 2 (continued)

Author Year Country	Age Breast cancer stage	Number of participants	Measures	Assessment	Type of exercise	Exercise period	Nutrition focus Nutrition consultation/ education timeline	Nutrition inter- vention method	Outcomes
Wilkie et al 2022 USA [43]	> 18 years 0–IV	Total: 109 for BC Received RT: 134 (NR how many were BC patients)	Fatigue	Schwartz Cancer Fatigue Scale	Self-reported varied exercise	4 weeks, ses- sions varied per participant, 15–30 min per session			No change in fatigue
Ratcliff et al 2016 USA [44]	> 18 years 0–III	Total: 163 Received RT: 163	HRQoL/QoL; insomnia/trouble sleeping; depres- sion; cortisol rhythmicity; post-traumatic responses	SF-36; CES-D Scale; Impact of Event Scale; saliva samples	Yoga	6 weeks, 3 sessions per week, 60 min per session			Improvement in QoL; depres- sion; sleep quality
Yang et al 2015 Taiwan [45]	Mean: 50.3 years NR	Total: 58 Received RT: 58	Fatigue	BFI	Aerobic/cardio- vascular (low intensity); Aerobic/car- diovascular (moderate intensity)	6 weeks, 3 sessions per week, 50–60 min per session			Reduction in fatigue
Zhang et al 2023 China [46]	> 18 years I–IV	Total: 184 Received RT: 184	HRQoL/QoL; fatigue; anxiety	HADS; EORTC QLQ C-30; CFS	Aerobic/car- diovascular (intensity not reported); resistance/ strength train- ing; stretching	5 weeks, 7 sessions per week, 60 min per session			Improvement in QoL Reduction in fatigue; depression No change in anxiety
<b>Continued after cessation of active RT treatment/not specified</b>									
Anderson et al 2012 USA [47]	> 18 years I–III	Total: 104 Received RT: 67	HRQoL/QoL; physical function- ing; shoulder/arm ROM	PFS; callipers	Walking; aero- bic/cardiovas- cular (intensity not reported); resistance/ strength train- ing; stretching	18 months, 2 sessions per week for first 3 months, followed by option to tran- sition to home- based exercise			Improvement in physical functioning No change to QoL; arm cir- cumference

Table 2 (continued)

Author Year Country	Age Breast cancer stage	Number of participants	Measures	Assessment	Type of exercise	Exercise period	Nutrition focus	Nutrition consultation/ education timeline	Nutrition inter- vention method	Outcomes
Battaglini et al 2008 USA [48]	35–70 years 'Recent Diagnosis'	NR	Fatigue; body composition; total caloric intake	Food dairy; cal- lipers; PFS	Resistance/ strength train- ing; stretching; cardiovascu- lar—intensity based on Exercise and Cancer Recov- ery Guidelines	6 months, 2 sessions per week; 60 min per session				Reduction in fatigue Increase in total caloric intake Change in body composition
Cadmus et al 2009 USA [49]	35–75 years 0–III	Total: Group 1 (IMPACT): 75 Received RT: 16	HRQoL/QoL; anxi- ety; depression; stress; self- esteem; physical functioning	FACT-B; 2-item Fordyce Happi- ness Measure; Rosenberg Self- Esteem Scale; CES-D; STAI; Perceived Stress Scale; SF-36	Walking; aerobic/car- diovascular (moderate intensity)	Both groups: 6 months, 2–5 sessions per week, 30 min per session				IMPACT: No change in QoL YES: No change in QoL
Campbell et al 2005 UK [50]	Average: 47–48 years NR	Group 2 (YES): 50 Received RT: 24 Total: 16 Received RT: NR	HRQoL/QoL; fatigue; physical functioning	FACT-G; FACT- B; PFS; SWLS	Walking; aerobic/car- diovascular (low intensity); resistance/ strength train- ing	12 weeks, 2 sessions per week, ~30 min per session				Improvement in QoL; physical functioning Reduction in fatigue
Cešaiķo et al 2020 Latvia [51]	18–63 years I–III	Total: 55 Received RT: 49	HRQoL/QoL; physical function- ing	The 6-min walk- ing distance; 30 s sit to stand test; Skin-fold calliper	Walking; other: maximal strength train- ing	12 weeks, 2 sessions per week, 20 min per session				Not clear
Cešaiķo et al 2019 Latvia [52]	18–63 years I–III	Total: 55 Received RT: 49	HRQoL/QoL	EORTC QLQ C-30; EORTC QLQ-BR23	Resistance/ strength train- ing	12 weeks, 2 sessions per week, 20 min per session				Improvement in QoL; fatigue

Table 2 (continued)

Author Year Country	Age Breast cancer stage	Number of participants	Measures	Assessment	Type of exercise	Exercise period	Nutrition focus	Nutrition consultation/education timeline	Nutrition intervention method	Outcomes
Emslie et al 2007 UK [53]	40–76 years 'Early stage'	Total: 203 Received RT: 33	HRQoL/QoL; body image; mood state; physical functioning; shoulder/arm ROM	Focus groups	NR	12 weeks, 2 sessions per week, 30 min per session				Respondents described the benefits they had gained: positive mental states; better physical functioning; improved sleep; improved confidence; feeling more in control
Gollhofer et al 2015 Germany [54]	>18 years 0–III	Total: 117 Received RT: 117	Fatigue	FAQ	Resistance/strength training	12 weeks, sessions per week, and session durations NR				No change in fatigue
Grabnbauer et al 2016 Germany [55]	>18 years NR	NR	HRQoL/QoL; body composition	EORTC QLQ C-30; BIA	Aerobic/cardiovascular (intensity not reported)	12 months, 2–3 sessions per week, 30–60 min per session				Improvement in QoL; body composition
Haines et al 2010 Australia [56]	55.9 ± 10.5 years (study), 54 ± 11.5 years (control) NR	Total: 89 Received RT: 82	HRQoL/QoL; fatigue; body composition; upper limb swelling	EORTC QLQ C-30; Multidimensional Fatigue Index; BIA	Aerobic/cardiovascular (intensity not reported); resistance/strength training; shoulder mobility and balance	Weeks/sessions per week NR -36 min DVD instruction + 20 min of walking				Improvement in QoL; physical functioning Reduction in fatigue; upper limb swelling
Jain et al 2023 India [57]	Mean: 43 years (study) and 47 years (control) II–III	Total: 96 Received RT: 67	Fatigue; physical functioning	EORTC QLQ C-30; EORTC QLQ-FA12	Yoga	48 weeks, 5 sessions per week, 50 min per session				Improvement in fatigue; physical functioning
Kilbreath et al 2012 Australia [58]	Mean: 51.6–53.5 years 0–III	Total: 160 Received RT: 157	Shoulder/arm ROM	Digital inclinometer	Resistance/strength training; stretching	8 weeks, 7 sessions per week, session duration NR				Improvement in ROM

Table 2 (continued)

Author Year Country	Age Breast cancer stage	Number of stage participants	Measures	Assessment	Type of exercise	Exercise period	Nutrition focus	Nutrition consultation/ education timeline	Nutrition inter- vention method	Outcomes
Lee et al 2008 USA [59]	> 18 years I–III	Total: 112 Received RT: 59	Nausea	Self-report diary/ log, INVR	Aerobic/car- diovascular (moderate intensity)	12 months, 3 sessions per week, 20 min per session				Reduction in nausea
Lötzke et al 2016 Germany [60]	NR I–III	Total: 92 Received RT: 26	HRQoL/QoL; fatigue; life satisfaction, mindfulness, and spirituality	EORTC QLQ C-30; BLMSS; CFS-D; FMI	Yoga; physical exercise	Both groups: 12 weeks; 3 sessions per week; 20–60 min per session				Improvement in QoL for both groups No change in fatigue; life satisfaction; spirituality and mindful- ness for either group
Malik et al 2023 India [61]	32–70 years II–III	Total: 100 Received RT: 100	HRQoL/QoL	QOL-CSV	Walking; aerobic/car- diovascular (moderate intensity)	Weeks/sessions per week NR, 20 min per day				Improvement in QoL (specifi- cally fatigue; pain; sleep quality; consti- pation)
Mavropalias et al 2023 Australia [62]	32–78 years I–III	Total: 106 Received RT: 106	HRQoL/QoL; fatigue	FACT-B; FACIT- F; PSQI	Aerobic/car- diovascular (moderate intensity); resistance/ strength train- ing	12 weeks, 3–5 sessions per week, 20–30 min per session				Improvement in QoL Reduction in fatigue
Rao et al 2017 India [63]	30–70 years II–III	Total: 98 Received RT: 67	HRQoL/QoL; anxi- ety; depression; physical function- ing	STAI; BDI; FLJC	Yoga	24 weeks, 3 ses- sions per week (during RT), 60 min per session				Improvement in QoL Reduction in anxiety; depression; stress; treat- ment-related symptoms and toxicity
Rao et al 2015 India [64]	30–70 years II–III	Total: 98 Received RT: 67	Depression	BDI	Yoga	24 weeks, 3 ses- sions per week (during RT), 60 min per session				Reduction in depression

Table 2 (continued)

Author Year Country	Age Breast cancer stage	Number of participants	Measures	Assessment	Type of exercise	Exercise period	Nutrition focus	Nutrition consultation/ education timeline	Nutrition inter- vention method	Outcomes
Rao et al 2009 India [65]	30–70 years II–III	Total: 98 Received RT: 67	Anxiety; Symptom distress	STAI; subjective symptom checklist (for treatment- related side effects, prob- lems with sexu- ality and image, and relevant psychological and somatic symptoms related to breast cancer)	Yoga	24 weeks, 3 ses- sions per week (during RT), 60 min per session				Reduction in anxiety; symp- tom distress
Reis et al 2013 USA [66]	> 18 years I–III	Total: 41 Received RT: 41	HRQoL/QoL; fatigue; shoulder/ arm ROM	FACT-G, FACIT- F; Goniometer	Aerobic/car- diovascular (intensity not reported); Nia exercise	12 weeks, 3 sessions per week, 20–60 min per session				Reduction in fatigue No change in QoL; ROM
Schmidt et al 2016 Germany [67]	> 18 years 0–III	Total: 160 Received RT: 160	Fatigue; depression; pain	FAQ	Resistance/ strength train- ing	12 weeks, 2 sessions per week, 60 min per session				Reduction in fatigue; pain
Spence et al 2022 Australia [68]	> 18 years II–IV	Total: 60 Received RT: 45	HRQoL/QoL	PROMIS	Walking; aerobic/car- diovascular (low intensity); resistance/ strength train- ing	12 weeks, 3–4 sessions per week on average, 20–40 min per session				Improvement in QoL
Steindorf et al 2017 Germany [69]	> 18 years 0–III	Total: 160 Received RT: 160	Sleep quality	EORTC QLQ C-30; FAQ	Resistance/ strength train- ing	12 weeks, 2 sessions per week, 60 min per session				Improvement in sleep quality
Steindorf et al 2014 Germany [70]	> 18 years 0–III	Total: 160 Received RT: 160	HRQoL/QoL; fatigue; depres- sion	EORTC QLQ C-30; EORTC QLQ-BR23; CES-D Scale	Resistance/ strength train- ing	12 weeks, 2 sessions per week, 60 min per session				Improvement in QoL Reduction in fatigue

Table 2 (continued)

Author Year Country	Age Breast cancer stage	Number of stage participants	Measures	Assessment	Type of exercise	Exercise period	Nutrition focus	Nutrition consultation/ education timeline	Nutrition inter- vention method	Outcomes
Vehmanen et al 2022 Finland, Portugal, Israel, and Italy [71]	40–70 years IA–IIIB	Total: 311 Received RT: 247	HRQoL/QoL; physical function- ing	HADS; EORTC QLQ C-30; EORTC QLQ- BR23	Aerobic/cardio- vascular (low intensity); Aerobic/car- diovascular (moderate intensity)	Varied per participant – self-reported				Improvement in QoL Reduction in depression; anxiety
Winters-Stone et al 2018 USA [72]	> 18 years 0–IV	Total: 90 Received RT: 43	Fatigue; Depres- sion; Mood state	Brief Profile of Mood States	Yoga	8 weeks, 3 sessions per week, 30 min per session				Improvement in mood state; depression Reduction in fatigue
Wiskemann et al 2017 Germany [73]	Mean: 55.2 0–III	Total: 146 Received RT: 146	Fatigue; Weight change; Body composition; Physical function- ing; Shoulder/arm ROM	Scales/measure- ment; FAQ; BMI	Resistance/ strength train- ing	12 weeks, ses- sions NR on				Improvement in ROM Reduction in weight (slight) No change in fatigue
<b>'Nutrition-only' studies</b>										
Klement et al 2020 Germany [74]	18–75 years NR	Total: 63 Received RT: 63	HRQoL/QoL; Weight change; Body composition	Self-report diary/ log; BIA; Blood sample; EORTC QLQ C-30; EORTC QLQ- BR23			Ketogenic diet	Consulta- tion and education (handouts) at baseline only	Generic (all parti- pants receive same advice)	Improvement in QoL Decreased body weight
Rockenbach et al 2011 Brazil [75]	35–77 years 0–III	Total: 40 Received RT: 24	Weight change; Oxidative stress; BMI	Scales/measure- ment; blood sample; FFQ adapted from the Sichert and Everhart vali- dated question- naire			Guidance on healthy eat- ing; changes in dietary intake pre and post treatment; weight/body composition	Consulta- tion at baseline only	Generic (all parti- pants receive the same advice)	Dietary intake changes (increase in meat and eggs, dairy products, beans, oils, and fats) Increased body weight Increase in stress

Table 2 (continued)

Author Year Country	Age Breast cancer stage	Number of participants	Measures	Assessment	Type of exercise	Exercise period	Nutrition focus	Nutrition consultation/ education timeline	Nutrition inter- vention method	Outcomes
<b>Combined exercise and nutrition studies</b>										
<b>During active RT treatment only (period in which patient is receiving RT)</b>										
Klement et al 2021 Germany [76]	<75 years NR	Total: 44 Received RT: 44	HRQoL/QoL; weight change; body composition; other: vitamin D levels, metabolic blood parameters and hormones	Self-report diary/ log; BIA; blood sample; EORTC QLQ C-30; Diary log kept for both nutri- tion and exercise	Walking; Bike rides	'Length of RT' – weeks NR, 7 sessions per week, 30 min per session	Palaeolithic diet	Education (handouts) at baseline only	Generic (all participants receive same advice)	Improvement in QoL Increase in vitamin D Decreased body weight Reduction in free T3 hor- mone levels; blood glucose; triglycerides; low-density lipoprotein cholesterol; C-reactive pro- tein levels
<b>Continued after cessation of active RT treatment</b>										
Carayol et al 2019 France [77]	18– 75 years I–III	Total: 143 Received RT: 143	HRQoL/QoL; fatigue; anxiety; depression; body composition; BMI	BIA; GPAQ; Device (acceler- ometer); HADS; EORTC QLQ C-30; MFI; Nutritional Analysis Soft- ware; 10-point visual analogue scale	Resistance/ strength train- ing; stretching; cardiovascu- lar—intensity based on Exer- cise and Cancer Recovery Guidelines	6 months, 2 sessions per week; 60 min per session	Healthy eating based on World Cancer Research Fund recommenda- tion	Application NR—base- line and periodic	Generic (all participants receive same advice)	Improvement in QoL; depres- sion; anxiety Reduction in fatigue; BMI
Jacot et al 2020 France [78]	> 18 years 0–IV	Total: 360 Received RT: 360	HRQoL/QoL; Fatigue; Weight change; Body composition	Self-report diary/ log; GPAQ; Nutritional Analysis Soft- ware; HADS; EORTC QLQ C-30, MFI; MFI-20	Walking; Jogging/ running; aero- bic/cardiovas- cular (moderate intensity); resist- ance/strength training; danc- ing; stretch- ing; cycling; swimming	26 weeks (dur- ing CT and RT), 2 sessions per week, 60 min per session	Healthy eating based on World Cancer Research Fund recommenda- tion	6 consulta- tions (during CT and RT), each con- sultation involved an evalua- tion of nutritional status, nutrition care tai- lored to the patient	Tailored – consulta- tions taught principles of a well-balanced diet, fostered weight control during treat- ment and induced appro- priate feeding behaviours after treatment	No change in QoL; fatigue; depression; anxiety; body weight Dietary intake changes (increase in fibre and reduction in animal proteins and alcohol)

Table 2 (continued)

Author Year Country	Age Breast cancer stage	Number of participants	Measures	Assessment	Type of exercise	Exercise period	Nutrition focus	Nutrition consultation/ education timeline	Nutrition intervention method	Outcomes
Kirkham et al 2019 Canada [79]	29– 77 years 0–III	Total: 73 Received RT: 67	HRQoL/QL; weight change; body composition	Scales/measurement; FACT-B; SF-36	Aerobic/cardiovascular (intensity not reported); resistance/strength training	Phase 1: Length of CT/RT, 3 sessions per week, 15–30 min per session  Phase 2: 10 weeks, 2 sessions per week, 15–30 min per session  Phase 3: 10 weeks, 1 session per week, 15–30 min per session	Achieving adherence to Canada's Food Guide and Canadian Cancer Society guidelines, and Dietary Reference Intake	Consultation (with dietitian) at baseline only—2-h session  Generic (all participants receive same advice)	Improvement in QoL No change in body weight	

*BDI* Beck's Depression Inventory, *BFS* Benefit Finding Scale, *BIA* bioelectrical impedance analysis, *BMI* body mass index, *BC* breast cancer, *BFI* Brief Fatigue Inventory, *BMLSS* Brief Multidimensional Life Satisfaction Scale, *CFS-D* Cancer Fatigue Scale, *CFS* Cancer-related Fatigue Scale, *CES-D* Centre for Epidemiologic Studies Depression Scale, *CT* chemotherapy, *EORTC QLQ FAI/2* EORTC Core QoL Cancer Related Fatigue Questionnaire, *EORTC QLQ C-30* EORTC Core QoL Questionnaire, *EORTC QLQ-BR23* European Organisation for Research and Treatment of Cancer-Breast Module, *FAQ* Fatigue Assessment Questionnaire, *FSI* Fatigue Symptom Inventory, *FMI* Freiburg Mindfulness Inventory, *FACT-B* Functional Assessment of Cancer Therapy-Breast, *FACT-G* Functional Assessment of Cancer Therapy-General, *FACT-F* Functional Assessment of Chronic Illness Therapy-Fatigue questionnaire, *FLIC* Functional Living Index of Cancer, *GPAQ* Global Physical Activity Questionnaire, *HADS* Hospital anxiety and depression scale, *IES* Impact of Events Scale, *INVR* Index of Nausea, Vomiting, and Retching, *MOS SF-36* Medical Outcomes Study Short Health Form, *MFI* Multidimensional Fatigue Inventory, *NR* not reported, *PROMIS* Patient Reported Outcomes Measurement Information System, *PFS* Piper Fatigue Scale, *PSQI* Pittsburgh Sleep Quality Index, *PANAS* Positive and Negative Affect Schedule, *POMS* Profile of Mood States, *QOL-CSV* Quality of Life Patient/Cancer Survivor Version



supervised by a physiotherapist or exercise physiologist, and 9% ( $n = 5$ ) were supervised by a registered nurse.

Studies that implemented interventions with aerobic/cardiovascular exercise and resistance/strength training were those to find the most improvements in QoL (11 of 16 studies and 9 of 14, respectively). This was also found in the improvement of fatigue (9 of 16 studies that implemented aerobic exercise and 8 of 14 for resistance/strength). It is noteworthy that the studies that implemented yoga resulted in a wide range of psychological improvements, such as depression, stress, anxiety, sleep quality, and cortisol levels, in addition to QoL and fatigue. Studies that utilised interventions such as Kinesiotherapy and Mat Pilates only found improvement in shoulder ROM and pain, respectively. All relationships between exercise interventions and outcomes can be seen in Fig. 2.

### Nutrition-only studies

Only two studies in this review were 'nutrition-only' interventions. Klement et al. implemented a Ketogenic (or Keto) diet which consisted of giving all participants generic advice to adhere to the Keto diet. This study found decreased body weight and improved QoL. The remaining study, by Rockenbach et al., comprised participants receiving guidance on healthy eating (following the Dietary Guide for the Brazilian Population) at baseline only. Increased body weight and increased stress were reported in this study.

### Combined exercise and nutrition studies

Four studies implemented exercise and nutrition as combined interventions. Two studies, by Carayol et al. and Jacot et al., comprised education and counselling to meet the World Cancer Research Fund [80] recommendations, in conjunction with planned supervised aerobic/cardiovascular and muscle strength exercise, throughout the duration of the participants' treatment. While these studies implemented the same intervention, the outcome measures were different. One study found improvement in QoL and reduction in fatigue; the other found no change in QoL, fatigue, depression, anxiety, and body weight. Kirkham et al. implemented a singular 2-hour, group-based education session on healthy eating, to align with Canada's Food Guide, Canadian Cancer Society Guidelines, and Dietary Reference Intake. The exercise component consisted of supervised aerobic and whole-body resistance sessions, with encouragement of home-based exercise to work toward achieving the National Comprehensive Cancer Network recommendations [81]. This study found improvement in QoL and no body weight changes. The final study by Klement et al. recommended the Palaeolithic diet (which consists of the consumption of fatty meats and organ meats from humanely raised animals, wild-caught fish, eggs, nuts

and seeds, algae, spices, vegetables, and fruits. Excluding processed foods, grains of all types, legumes, and vegetable oils except for native coconut and olive oil and dairy products except for ghee) in conjunction with outdoor activity (walking or bike riding), 30 min per day. It was found that this intervention increased vitamin D and improved QoL. In addition, reduced body weight, T3 hormone levels, blood glucose, triglycerides, low-density lipoprotein cholesterol, and C-reactive protein levels were reported.

## Discussion

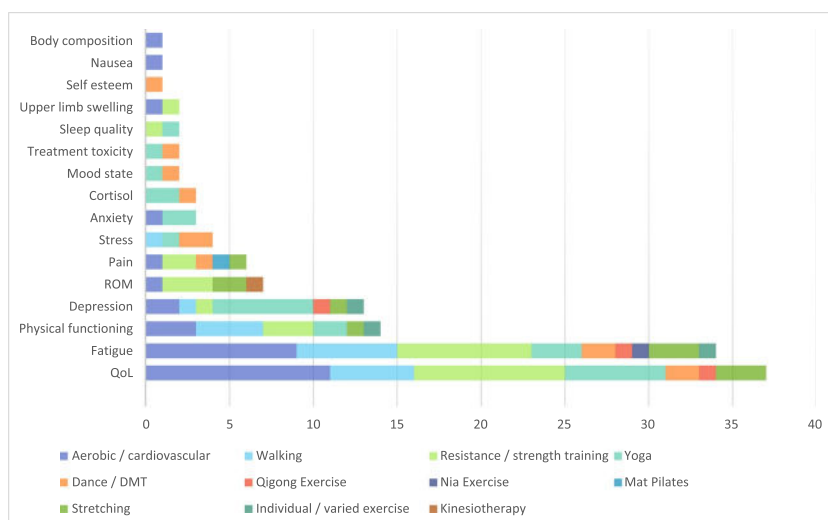
This scoping review aimed to find literature reporting on exercise and/or nutritional interventions implemented during radiation therapy for women with breast cancer. It was discovered that most studies utilised exercise interventions (90%;  $n = 52$ ) while only a small proportion had nutrition interventions (3%;  $n = 2$ ). Moreover, only a limited number of studies (7%;  $n = 4$ ) have explored the potential benefits of combining these interventions. While exercise and nutrition interventions are extensively recognised in cancer prevention and survivorship settings [82, 83], this review demonstrates that they are not routinely used during treatment and rarely together.

### Active treatment vs. survivorship

In the systematic review by Barchitta et al., combined exercise and nutritional interventions are investigated in breast cancer survivors (post-active treatment) for the effect on QoL outcomes [84]. It was reported that most studies recommended various combinations of regular daily activity and healthy diets. More specifically, multiple studies utilised the American Cancer Society dietary guidelines (to consume vegetables, fruits, and whole grains regularly) [85], while other studies provided dietary counselling or recommendations [86]. Alongside this, several studies implemented supervised aerobic exercise regimes [87, 88], while others gave exercise or physical activity advice [89]. These studies consistently reported positive outcomes, such as reduced fatigue and depression, improved QoL, and enhanced overall emotional functioning in survivors [84].

However, comparing the QoL of survivors and those actively receiving radiation therapy can be difficult. This is due to the acute side effects of treatment and the potential effect on the QoL of patients during the active treatment stage. A two-phase study by Van Leeuwen et al. reported findings from a review of literature surrounding cancer survivorship and responses to interviews of disease-free cancer survivors. It was reported that most acute disease symptoms and treatment-related side effects had resolved

**Fig. 2** Relationship between exercise type and outcome, for ‘exercise-only’ studies



by approximately 12 months following treatment. These findings led to the development of a questionnaire specifically designed to target survivors, excluding questions typically intended to capture acute disease and treatment-related complications, as they were considered irrelevant to survivors [90]. Similarly, a qualitative study by Bloom et al. reports on interviews with 185 women with breast cancer (55%;  $n = 101$  received RT) at two different timeframes: during initial diagnosis/treatment and then 5 years later. Findings indicate that participants' physical and mental well-being improved between the different stages, especially in the areas of surgical side effects, body image concern, and 'worry about the future' [91]. Ensuring comprehensive support is accessible to patients during survivorship is crucial and a necessary focus, due to the increasing survival rate of breast cancer. However, interventions such as exercise and nutrition that have shown benefits during active treatment could be implemented much earlier, engaging patients during their treatment and aiming to continue into survivorship.

### Exercise and nutrition in cancer

A systematic review by Baguley et al. found 20 studies addressing the effect of nutrition therapy and exercise on cancer-related fatigue and QoL in men with prostate cancer during treatments. Consistent with our review, most studies focussed on exercise-only interventions (80%;  $n = 16$ ), and the remaining 20% were either nutrition-only (5%;  $n = 1$ ) or a combination of both (15%;  $n = 3$ ). Of the exercise-only interventions, they found aerobic, or resistance training programs were the most utilised [92]. Likewise, in our review, aerobic training (20%;  $n = 10$ ) and resistance training (22%;  $n = 11$ ) were the most reported. While this review closely reflects the results presented in our review, it is important to note that the needs

of women with breast cancer and men with prostate cancer can be vastly different. Baguley et al. focused on measures of cancer-related fatigue and overall quality of life, whereas our review aimed to capture all aspects of QoL possible. This approach was taken to provide comprehensive evidence to optimally support women holistically. A review by Browall et al. reported on 17 qualitative studies focusing on exercise during or after chemotherapy treatment for breast cancer. The interventions were group-based or personalised programs and comprised mindfulness movement, aerobics, and resistance training. Browall et al. found decreased fatigue, stress, and increased confidence and sense of control were common outcomes among the studies reviewed [93]. Similarly, a systematic review by Gilmour et al. reported on nutritional support for women receiving chemotherapy for breast cancer. They identified several chemotherapy-induced nutritional challenges women face, including changes in taste, appetite, nutritional status, and weight gain. Approaches to supporting women by providing nutritional interventions and education were also reviewed, affirming these practices may influence eating habits and improve treatment side effects [94].

### Implementing exercise and nutritional support

The nutrition-focused studies outlined in this scoping review illustrated changes in eating patterns (e.g., Palaeolithic diet, Ketogenic diet) implemented during RT treatment. However, as there were no measures of habitual dietary intake at baseline, the impact of these changes is difficult to interpret. In addition, most were administered with minimal or no support from qualified dietitians. As women with breast cancer receiving radiation therapy are in vulnerable circumstances, this level of change to a person's eating patterns could be contra-indicated and lead to outcomes that are not conducive to the treatment phase, rather than an improvement. Not having the appropriate qualified

professionals supporting the changes could also impose another level of stress. A qualitative study by Landmark et al. describes the experiences of ten women with newly diagnosed breast cancer, regarding social support. It was reported that participants found the ‘informative’ dimension (information, advice, and counselling) of social support instrumental in their ability to manage the burden of living with breast cancer [95]. Furthermore, Keaver et al. report a mixed methods (survey and focus groups) study regarding nutritional support and intervention preferences of cancer survivors, for which 27% ( $n = 15$ ) of participants professed to be interested in receiving nutritional advice via live online sessions, followed by 20% ( $n = 11$ ) preferring face-to-face personalised advice [96]. Therefore, we can see there is reported interest in nutrition to support the treatment journey in breast cancer; however, what types of changes are best suited to women with breast cancer receiving radiation therapy are not clear.

## Implications for future research

The findings of this scoping review provide valuable insights for informing practice, by mapping the current literature regarding exercise and/or nutrition interventions to improve QoL for women with breast cancer receiving RT. The primary focus of our review is shown to be on the impact of exercise on general QoL, fatigue, and depression. However, it is important to acknowledge that nutritional input and interventions also play a crucial role in ensuring the well-being of women with breast cancer, and this is a gap in the literature found by this review. Furthermore, there is a growing body of evidence that exercise and nutrition can decrease the chance of recurrence and improve cancer outcomes. In the context of women with breast cancer undergoing RT treatment, future research could explore the potential benefits of supporting women with exercise and nutrition intervention/s, as a standard approach, to not only enhance their QoL but improve their outcome.

## Conclusion

In conclusion, this review highlights the existing literature on investigations into the relationship between exercise, nutrition, and the QoL of women with breast cancer receiving RT, this review underscores that the existing evidence is not comprehensive, and further research in this area is warranted to improve women’s QoL and overall health and well-being.

## Strengths and limitations

The study selection process can cause bias, due to the subjective judgement of reviewers.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s00520-024-08933-1>.

**Author contribution** Laura Feighan, Lesley MacDonald-Wicks, Robin Callister and Yolanda Surjan contributed equally to the conceptualisation, data collection and analysis, manuscript preparation and review.

**Funding** Open Access funding enabled and organized by CAUL and its Member Institutions.

**Data availability** No datasets were generated or analysed during the current study.

## Declarations

**Conflict of interest** The authors declare no competing interests.

**Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

## References

1. Cancer Australia (2024) [Internet] NSW (AU): [publisher unknown]. Available from: <https://www.canceraustralia.gov.au/>. Accessed 12 Sept 2024
2. Balaji K, Subramanian B, Yadav P, AnuRadha C, Ramasubramanian V (2016) Radiation therapy for breast cancer: literature review. *Med Dosim* 41(3):253–257
3. Sourati A, Ameri A, Malekzadeh M (2017) Acute side effects of radiation therapy. Springer, Cham
4. Buchholz TA (2009) Radiation therapy for early-stage breast cancer after breast-conserving surgery. *N Engl J Med* 360(1):63–70
5. Whelan, T J, Levine, M, Julian, J, Kirkbride, P, Skingley, P, Group, O C O. The effects of radiation therapy on quality of life of women with breast carcinoma: results of a randomized trial. *Cancer*. 2000;88(10):2260-6
6. World Health Organisation. (2024) [Internet] (Geneva): [publisher unknown]. Available from: <https://www.who.int/>. Accessed 28 Feb 2024
7. Sosnowski R, Kulpa M, Ziętałewicz U, Wolski JK, Nowakowski R, Bakula R et al (2017) Basic issues concerning health-related quality of life. *Cent European J Urol* 70(2):206–211
8. Gavric Z, Vukovic-Kostic Z (2016) Assessment of quality of life of women with breast cancer. *Glob J Health Sci* 8(9):52792
9. Paraskevi T (2012) Quality of life outcomes in patients with breast cancer. *Oncol Rev* 6(1):e2
10. de Wit, M, Hajos, T. Health-related quality of life. In: Gellman MD, Turner JR, editors. *Encyclopedia of Behavioral Medicine*. New York, NY: Springer New York; 2013. p. 929–31
11. Nardin S, Mora E, Varughese FM, D’Avanzo F, Vachanaram AR, Rossi V et al (2020) Breast cancer survivorship, quality of life, and late toxicities. *Front Oncol* 10:864

12. Mikkelsen K, Stojanovska L, Polenakovic M, Bosevski M, Apostolopoulos V (2017) Exercise and mental health. *Maturitas* 106:48–56
13. Zavitsanou A, Drigas A (2021) Nutrition in mental and physical health. *Technium Social Sci J* 23(1):67–77
14. Ruegsegger GN, Booth FW (2018) Health benefits of exercise. *Cold Spring Harb Perspect Med* 8(7):a029694
15. Milte CM, Thorpe MG, Crawford D, Ball K, McNaughton SA (2015) Associations of diet quality with health-related quality of life in older Australian men and women. *Exp Gerontol* 64:8–16
16. Sadeghi F, Mockler D, Guinan EM, Hussey J, Doyle SL (2021) The effectiveness of nutrition interventions combined with exercise in upper gastrointestinal cancers: a systematic review. *Nutrients* 13(8):2842
17. Bye A, Sandmael JA, Stene GB, Thorsen L, Balstad TR, Solheim TS et al (2020) Exercise and nutrition interventions in patients with head and neck cancer during curative treatment: a systematic review and meta-analysis. *Nutrients* 12(11):3233
18. Sharma GN, Dave R, Sanadya J, Sharma P, Sharma K (2010) Various types and management of breast cancer: an overview. *J Adv Pharm Technol Res* 1(2):109–126
19. Waks AG, Winer EP (2019) Breast cancer treatment: a review. *JAMA* 321(3):288–300
20. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D et al (2018) PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med* 169(7):467–473
21. Richardson WS, Wilson MC, Nishikawa J, Hayward RS (1995) The well-built clinical question: a key to evidence-based decisions. *ACP J Club* 123(3):A12–A13
22. Adams-Campbell LL, Hicks J, Makambi K, Randolph-Jackson P, Mills M, Isaacs C et al (2023) An 8-week exercise study to improve cancer treatment related fatigue and QOL among African American breast cancer patients undergoing radiation treatment: a pilot randomized clinical trial. *J Natl Med Assoc* 115(2):199–206
23. Addington EL, Sohl SJ, Tooze JA, Danhauer SC (2018) Convenient and Live Movement (CALM) for women undergoing breast cancer treatment: challenges and recommendations for internet-based yoga research. *Complement Ther Med* 37:77–79
24. Banerjee B, Vadiraj HS, Ram A, Rao R, Jayapal M, Gopinath KS et al (2007) Effects of an integrated yoga program in modulating psychological stress and radiation-induced genotoxic stress in breast cancer patients undergoing radiotherapy. *Integr Cancer Ther* 6(3):242–250
25. da Silva Braz, Leal NF, de Oliveira HF, Angotti Carrara HH (2016) Supervised physical therapy in women treated with radiotherapy for breast cancer. *Revista Latino-Americana de Enfermagem (RLAE)* 24:1–8
26. Chandwani KD, Thornton B, Perkins GH, Arun B, Raghuram NV, Nagendra HR et al (2010) Yoga improves quality of life and benefit finding in women undergoing radiotherapy for breast cancer. *J Soc Integr Oncol* 8(2):43–55
27. Chandwani KD, Perkins G, Nagendra HR, Raghuram NV, Spelman A, Nagarathna R et al (2014) Randomized, controlled trial of yoga in women with breast cancer undergoing radiotherapy. *J Clin Oncol* 32(10):1058–1065
28. Chen Z, Meng Z, Milbury K, Bei W, Zhang Y, Thornton B et al (2013) Qigong improves quality of life in women undergoing radiotherapy for breast cancer: results of a randomized controlled trial. *Cancer* 119(9):1690–1698
29. Drouin JS, Armstrong H, Krause S, Orr J, Birk TJ, Hryniuk WM et al (2005) Effects of aerobic exercise training on peak aerobic capacity, fatigue, and psychological factors during radiation for breast cancer. *Rehab Oncol* 23(1):11–17
30. Ho, R T H, Fong, T C T, Cheung, I K M, Yip, P S F, Luk, M-y. Effects of a short-term dance movement therapy program on symptoms and stress in patients with breast cancer undergoing radiotherapy: a randomized, controlled, single-blind trial. *J Pain Symptom Manage* 2016;51(5):824–31
31. Hwang JH, Chang HJ, Shim YH, Park WH, Park W, Huh SJ et al (2008) Effects of supervised exercise therapy in patients receiving radiotherapy for breast cancer. *Yonsei Med J* 49(3):443–450
32. Ho RTH, Lo PHY, Luk MY (2016) A good time to dance? A mixed-methods approach of the effects of dance movement therapy for breast cancer patients during and after radiotherapy. *Cancer Nurs* 39(1):32–41
33. Ho RTH, Fong TCT, Yip PSF (2018) Perceived stress moderates the effects of a randomized trial of dance movement therapy on diurnal cortisol slopes in breast cancer patients. *Psychoneuroendocrinology* 87:119–126
34. Kulkarni N, Mahajan AA, Khatri SM (2013) A randomized controlled trial of the effectiveness of aerobic training for patients with breast cancer undergoing radiotherapy. *J Assoc Chartered Physiotherapists Women's Health* 113:42–50
35. Oliveira MM, Gurgel MS, Miranda MS, Okubo MA, Feijó IL, Souza GA (2009) Efficacy of shoulder exercises on locoregional complications in women undergoing radiotherapy for breast cancer: clinical trial. *Braz J Phys Ther* 13:136–43
36. Mock V, Pickett M, Ropka ME, Lin EM, Rhodes VA, McDaniel R et al (2001) Fatigue and quality of life outcomes of exercise during cancer treatment. *Cancer Pract* 9(3):119–127
37. Mock V, Frangakis C, Davidson NE, Ropka ME, Pickett M, Poniatowski B et al (2005) Exercise manages fatigue during breast cancer treatment: a randomized controlled trial. *Psychooncology* 14(6):464–477
38. Pickett M, Mock V, Ropka ME, Cameron L, Coleman M, Podewils L (2002) Adherence to moderate-intensity exercise during breast cancer therapy. *Cancer Pract* 10(6):284–292
39. Raghavendra RM, Vadiraja HS, Nagarathna R, Nagendra HR, Rekha M, Vanitha N et al (2009) Effects of a Yoga program on cortisol rhythm and mood states in early breast cancer patients undergoing adjuvant radiotherapy: a randomized controlled trial. *Integr Cancer Ther* 8(1):37–46
40. Torres DM, de Menezes Fireman K, Fabro EAN, Thuler LCS, Koifman RJ, Bergmann A et al (2023) Effectiveness of mat pilates on fatigue in women with breast cancer submitted to adjuvant radiotherapy: randomized controlled clinical trial. *Support Care Cancer* 31(6):1–11
41. Vadiraja HS, Rao MR, Nagarathna R, Nagendra HR, Rekha M, Vanitha N et al (2009) Effects of yoga program on quality of life and affect in early breast cancer patients undergoing adjuvant radiotherapy: a randomized controlled trial. *Complement Ther Med* 17(5/6):274–280
42. VanderWalde NA, Martin MY, Kocak M, Morningstar C, Deal AM, Nyrop KA, Farmer M, Ballo M, VanderWalde A, Muss H (2021) Randomized phase II study of a home-based walking intervention for radiation-related fatigue among older patients with breast cancer. *J Geriatr Oncol* 12(2):227–234
43. Wilkie DJ, Schwartz AL, Liao WC, Fullwood D, Wu Y, Farquharson TW et al (2022) Reduced cancer-related fatigue after tablet-based exercise education for patients. *Cancer Control* 29:10732748221087054
44. Ratcliff CG, Milbury K, Chandwani KD, Chaoul A, Perkins G, Nagarathna R et al (2016) Examining mediators and moderators of yoga for women with breast cancer undergoing radiotherapy. *Integr Cancer Ther* 15(1):1
45. Yang TY, Chen ML, Li CC (2015) Effects of an aerobic exercise programme on fatigue for patients with breast cancer undergoing radiotherapy. *J Clin Nurs* 24(1–2):202–211
46. Zhang H, Meng Y, Jiang R, Ge S, Song M (2023) Effect of Multimodal exercise on cancer-related fatigue in patients undergoing simultaneous radiotherapy and chemotherapy: a randomized

- trial in patients with breast cancer. *Altern Ther Health Med* 29(5):233–237
47. Anderson RT, Kimmick GG, McCoy TP, Hopkins J, Levine E, Miller G et al (2012) A randomized trial of exercise on well-being and function following breast cancer surgery: the RESTORE trial. *J Cancer Surviv* 6(2):172–181
  48. Battaglini CL, Mihalik JP, Bottaro M, Dennehy C, Petschauer MA, Hairston LS et al (2008) Effect of exercise on the caloric intake of breast cancer patients undergoing treatment. *Brazilian J Med Biol Res Revista Brasileira De Pesquisas Medicas E Biologicas* 41(8):709–15
  49. Cadmus LA, Salovey P, Yu H, Chung G, Kasl S, Irwin ML (2009) Exercise and quality of life during and after treatment for breast cancer: results of two randomized controlled trials. *Psychooncology* 18(4):343–352
  50. Campbell A, Mutrie N, White F, McGuire F, Kearney N (2005) A pilot study of a supervised group exercise programme as a rehabilitation treatment for women with breast cancer receiving adjuvant treatment. *Eur J Oncol Nurs* 9(1):56–63
  51. Češeiko R, Thomsen SN, Tomsone S, Eglītis J, Vētra A, Srebnijs A et al (2020) Heavy resistance training in breast cancer patients undergoing adjuvant therapy. *Med Sci Sports Exerc* 52(6):1239–1247
  52. Češeiko R, Eglītis J, Srebnijs A, Timofejevs M, Purmalis E, Ertis R et al (2019) The impact of maximal strength training on quality of life among women with breast cancer undergoing treatment. *Exp Oncol* 41(2):166–172
  53. Emslie C, Whyte F, Campbell A, Mutrie N, Lee L, Ritchie D et al (2007) ‘I wouldn’t have been interested in just sitting round a table talking about cancer’: exploring the experiences of women with breast cancer in a group exercise trial. *Health Educ Res* 22(6):827–838
  54. Gollhofer SM, Wiskemann J, Schmidt ME, Klassen O, Ulrich CM, Oelmann J, Hof H, Potthoff K, Steindorf K (2015) Factors influencing participation in a randomized controlled resistance exercise intervention study in breast cancer patients during radiotherapy. *BMC cancer*. 15:1–9
  55. Grabenbauer A, Grabenbauer AJ, Lengenfelder R, Grabenbauer GG, Distel LV (2016) Feasibility of a 12-month-exercise intervention during and after radiation and chemotherapy in cancer patients: impact on quality of life, peak oxygen consumption, and body composition. *Radiat Oncol* 11:42
  56. Haines TP, Sinnamon P, Wetzig NG, Lehman M, Walpole E, Pratt T et al (2010) Multimodal exercise improves quality of life of women being treated for breast cancer, but at what cost? Randomized trial with economic evaluation. *Breast Cancer Res Treat* 124(1):163–175
  57. Jain M, Mishra A, Yadav V, Shyam H, Kumar S, Mishra SK, Ramakant P (2023) Long-term yogic intervention decreases serum interleukins IL-10 and IL-1 $\beta$  and improves cancer-related fatigue and functional scale during radiotherapy/chemotherapy in breast cancer patients: a randomized control study. *Support Care Cancer* 31(1):6
  58. Kilbreath SL, Refshauge KM, Beith JM, Ward LC, Lee M, Simpson JM et al (2012) Upper limb progressive resistance training and stretching exercises following surgery for early breast cancer: a randomized controlled trial. *Breast Cancer Res Treat* 133(2):667–676
  59. Lee J, Dodd MJ, Dibble SL, Abrams DI (2008) Nausea at the end of adjuvant cancer treatment in relation to exercise during treatment in patients with breast cancer. *Oncol Nurs Forum* 35(5):830–835
  60. Lötze, D, Wiedemann, F, Rodrigues Recchia, D, Ostermann, T, Sattler, D, Ettl, J, et al. Iyengar-Yoga compared to exercise as a therapeutic intervention during (neo)adjuvant therapy in women with stage I-III breast cancer: health-related quality of life, mindfulness, spirituality, life satisfaction, and cancer-related fatigue. *Evid Based Complement Alternat Med* 2016;2016 5931816
  61. Malik Y, Sen J, Mishra A, Bhandari V (2023) Effects of physical exercise on rehabilitation of cancer patients undergoing radiotherapy. *J Cancer Res Ther* 19(3):585–589
  62. Mavropalias G, Cormie P, Peddle-McIntyre CJ, Galvão DA, Taaffe DR, Schofield C et al (2023) The effects of home-based exercise therapy for breast cancer-related fatigue induced by radical radiotherapy. *Breast Cancer* 30(1):139–150
  63. Rao RM, Raghuram N, Nagendra HR, Kodaganur GS, Bilim-agga RS, Shashidhara HP et al (2017) Effects of a yoga program on mood states, quality of life, and toxicity in breast cancer patients receiving conventional treatment: a randomized controlled trial. *Indian J Palliat Care* 23(3):237–246
  64. Rao RM, Raghuram N, Nagendra H, Usharani M, Gopinath K, Diwakar R et al (2015) Effects of an integrated yoga program on self-reported depression scores in breast cancer patients undergoing conventional treatment: a randomized controlled trial. *Indian J Palliat Care* 21(2):174–181
  65. Rao MR, Raghuram N, Nagendra HR, Gopinath KS, Srinath BS, Diwakar RB et al (2009) Anxiolytic effects of a yoga program in early breast cancer patients undergoing conventional treatment: a randomized controlled trial. *Complement Ther Med* 17(1):1–8
  66. Reis D, Walsh ME, Young-McCaughan S, Jones T (2013) Effects of Nia exercise in women receiving radiation therapy for breast cancer. *Oncol Nurs Forum* 40(5):E374–E381
  67. Schmidt ME, Meynköhn A, Habermann N, Wiskemann J, Oelmann J, Hof H et al (2016) Resistance exercise and inflammation in breast cancer patients undergoing adjuvant radiation therapy: mediation analysis from a randomized, controlled intervention trial. *Int J Radiat Oncol Biol Phys* 94(2):329–337
  68. Spence RR, Sandler CX, Singh B, Tanner J, Pyke C, Eakin E, Vagenas D, Hayes SC (2022) A randomised, comparative, effectiveness trial evaluating low-versus high-level supervision of an exercise intervention for women with breast cancer: The SAFE Trial. *Cancers* 14(6):1528
  69. Steindorf K, Wiskemann J, Ulrich CM, Schmidt ME (2017) Effects of exercise on sleep problems in breast cancer patients receiving radiotherapy: a randomized clinical trial. *Breast Cancer Res Treat* 162(3):489–499
  70. Steindorf K, Schmidt ME, Klassen O, Ulrich CM, Oelmann J, Habermann N et al (2014) Randomized, controlled trial of resistance training in breast cancer patients receiving adjuvant radiotherapy: results on cancer-related fatigue and quality of life. *Ann Oncol* 25(11):2237–2243
  71. Vehmanen L, Mattson J, Karademas E, Oliveira-Maia AJ, Sousa B, Pat-Horenczyk R et al (2022) Associations between physical exercise, quality of life, psychological symptoms and treatment side effects in early breast cancer. *Breast J* 2022:9921575
  72. Winters-Stone KM, Moe EL, Perry CK, Medysky M, Pommier R, Vetto J et al (2018) Enhancing an oncologist’s recommendation to exercise to manage fatigue levels in breast cancer patients: a randomized controlled trial. *Support Care Cancer* 26(3):905–912
  73. Wiskemann J, Schmidt ME, Klassen O, Debus J, Ulrich CM, Potthoff K et al (2017) Effects of 12-week resistance training during radiotherapy in breast cancer patients. *Scand J Med Sci Sports* 27(11):1500–1510
  74. Klement RJ, Champ CE, Kämmerer U, Koebrunner PS, Krage K, Schäfer G, Weigel M, Sweeney RA (2020) Impact of a ketogenic diet intervention during radiotherapy on body composition: III—final results of the KETOCOMP study for breast cancer patients. *Breast Cancer Res* 22:1–4
  75. Rockenbach G, Di Pietro PF, Ambrosi C, Boaventura BC, Vieira FG, Crippa CG et al (2011) Dietary intake and oxidative stress in breast cancer: before and after treatments. *Nutricion hospitalaria : organo oficial de la Sociedad Espanola de Nutricion Parenteral y Enteral* 26(4):737–744

76. Klement RJ, Koebrunner PS, Krage K, Weigel MM, Sweeney RA (2021) Short-term effects of a Paleolithic lifestyle intervention in breast cancer patients undergoing radiotherapy: a pilot and feasibility study. *Med Oncol* 38(1):1–13
77. Carayol M, Ninot G, Senesse P, Bleuse JP, Gourgou S, Sancho-Garnier H, Sari C, Romieu I, Romieu G, Jacot W (2019) Short-and long-term impact of adapted physical activity and diet counseling during adjuvant breast cancer therapy: the “APAD1” randomized controlled trial. *BMC cancer* 19:1–20
78. Jacot W, Arnaud A, Jarlier M, Lefeuvre-plese C, Dalivoust P, Senesse P et al (2020) Brief hospital supervision of exercise and diet during adjuvant breast cancer therapy is not enough to relieve fatigue: a multicenter randomized controlled trial. *Nutrients* 12(10):1–24
79. Kirkham AA, Bland KA, Wollmann H, Bonsignore A, McKenzie DC, Van Patten C et al (2019) Maintenance of fitness and quality-of-life benefits from supervised exercise offered as supportive care for breast cancer. *JNCCN J Natl Compr Canc Netw* 17(6):695–702
80. World Cancer Research Fund (2024) [publisher unknown]. Available from: <https://www.wcrf.org/>. Accessed 2 Apr 2024
81. National Comprehensive Cancer Network (2024 ) [unknown]. Available from: <https://www.nccn.org/>. Accessed 2 Apr 2024
82. Bernstein L (2009) Exercise and breast cancer prevention. *Curr Oncol Rep* 11:490–496
83. Davies NJ, Batehup L, Thomas R (2011) The role of diet and physical activity in breast, colorectal, and prostate cancer survivorship: a review of the literature. *Br J Cancer* 105(1):S52–S73
84. Barchitta M, Maugeri A, Magnano San Lio R, Quattrocchi A, Degrassi F, Catalano F, Basile G, Agodi A (2020) The effects of diet and dietary interventions on the quality of life among breast cancer survivors: a cross-sectional analysis and a systematic review of experimental studies. *Cancers* 12(2):322
85. Kushi LH, Doyle C, McCullough M, Rock CL, Demark-Wahnefried W, Bandera EV et al (2012) American Cancer Society Guidelines on nutrition and physical activity for cancer prevention: reducing the risk of cancer with healthy food choices and physical activity. *CA Cancer J Clin* 62(1):30–67
86. Bauersfeld SP, Kessler CS, Wischnewsky M, Jaensch A, Steckhan N, Stange R et al (2018) The effects of short-term fasting on quality of life and tolerance to chemotherapy in patients with breast and ovarian cancer: a randomized cross-over pilot study. *BMC Cancer* 18(1):476
87. Swisher AK, Abraham J, Bonner D, Gilleland D, Hobbs G, Kurian S et al (2015) Exercise and dietary advice intervention for survivors of triple-negative breast cancer: effects on body fat, physical function, quality of life, and adipokine profile. *Support Care Cancer* 23(10):2995–3003
88. Ghavami H, Akyolcu N (2017) The impact of lifestyle interventions in breast cancer women after completion of primary therapy: a randomized study. *J Breast Health* 13(2):94–99
89. Travier N, Guillamo E, Oviedo GR, Valls J, Buckland G, Fonseca-Nunes A et al (2015) Is quality of life related to cardiorespiratory fitness in overweight and obese breast cancer survivors? *Women Health* 55(5):505–524
90. Van Leeuwen M, Husson O, Alberti P, Arraras JI, Chinot OL, Costantini A et al (2018) Understanding the quality of life (QOL) issues in survivors of cancer: towards the development of an EORTC QOL cancer survivorship questionnaire. *Health Qual Life Outcomes* 16(1):1–15
91. Bloom JR, Stewart SL, Chang S, Banks PJ (2004) Then and now: quality of life of young breast cancer survivors. *Psychooncology* 13(3):147–160
92. Baguley BJ, Bolam KA, Wright ORL, Skinner TL (2017) The effect of nutrition therapy and exercise on cancer-related fatigue and quality of life in men with prostate cancer: a systematic review. *Nutrients* 9(9):1003
93. Browall M, Mijwel S, Rundqvist H, Wengström Y (2018) Physical activity during and after adjuvant treatment for breast cancer: an integrative review of women’s experiences. *Integr Cancer Ther* 17(1):16–30
94. Gilmour F, Williams A (2018) Support with nutrition for women receiving chemotherapy for breast cancer. *British J Nursing* 27(4):S4–S9
95. Landmark BT, Strandmark M, Wahl A (2002) Breast cancer and experiences of social support. In-depth interviews of 10 women with newly diagnosed breast cancer. *Scand J Caring Sci* 16(3):216–23
96. Keaver L, O’Callaghan N, Douglas P (2023) Nutrition support and intervention preferences of cancer survivors. *J Hum Nutr Diet* 36(2):526–539

**Publisher’s Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.