Physical Activity, Exercise, and Health-Related Quality of Life in People Living with Breast Cancer

Alba Esteban-Simón and Alberto Soriano-Maldonado

Contents

Abstract

Physical activity (PA) interventions have shown to be effective for improving health-related quality of life (HRQoL) in clinical populations, including people living with cancer. This chapter summarizes the current PA guidelines and the current evidence about exercise interventions aimed to improve HRQoL in people with breast cancer (BC). In people with BC undergoing systemic treatments and in BC survivors, exercise interventions including aerobic exercise, high-intensity interval training, resistance training, and aerobic exercise combined with resistance training improve HRQoL. Compelling evidence supports the need for undertaking PA as a health-related behavior and implementing exercise interventions in this

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C. R. Martin et al. (eds.), *Handbook of the Behavior and Psychology of Disease*,
https://doi.org/10.1007/978-3-031-32046-0_66-1

population, particularly aerobic and resistance training. Mind-body practices and aquatic exercise might also improve HRQoL, although with smaller effects. Combining exercise with dietary interventions has also shown to have beneficial effects on all HRQoL domains in BC survivors. However, the benefits of PA on HRQoL in BC survivors are not maintained over time if PA is discontinued, which suggests that PA should become a daily habit in this population.

Keywords

Breast cancer · Physical activity · Aerobic exercise · High-intensity interval training · Resistance training · Concurrent training · Yoga · Tai Chi Chuan · Baduanjin · Aquatic exercise · Health

Abbreviations

BC	Breast cancer
CI	Confidence interval
d	Cohen's d
EORTC QLQ-BR23	European Organization for Research and Treatment of Cancer Breast Cancer-specific Quality of Life Questionnaire
EORTC QLQ-C30	European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30
EQ-5D	EuroQoL-5d questionnaire
FACT-B	Functional Assessment of Cancer Therapy—Breast questionnaire
FACT-G	Functional Assessment of Cancer Therapy—General questionnaire
HIIT	High-intensity interval training
HRQoL	Health-related quality of life
p	p-value
PA	Physical activity
QoL	Quality of life
SF-12	12-Item Short Form Health Survey
SF-36	36-Item Short Form Health Survey
$VO_{2máx}$	Maximum oxygen consumption

Introduction

Breast cancer (BC) is one of the most challenging and incident diseases worldwide, particularly in women. In 2020, 2,261,419 people were diagnosed with BC (Global Cancer Observatory 2020a), and it is expected that 2,700,000 new patients will be diagnosed in 2030 (Global Cancer Observatory 2020b), which will join those individuals already dealing with BC and treatments. Breast cancer is defined as an out-of-control growth of cells in the breast (one or both breasts). Categorizing breast

tumors, the European Society for Medical Oncology (2018) proposes the classification presented in Fig. 1, based on the hormone receptor status and HER2 gene expression. These different BC types require different therapeutical approaches depending on the tumor's characteristics and the disease stage (American Cancer Society 2021). The most common treatment types are presented in Fig. 2 (American Cancer Society 2021).

During and after the abovementioned treatments, people experience a series of side effects that affect their physical and psychological health and have a great impact on daily life (European Society for Medical Oncology 2018; American Cancer Society 2021). The most common side effects during and after BC treatments are the loss of muscle mass and muscular strength, decrease in cardiorespiratory fitness, shoulder-arm disabilities, presence of lymphedema, fatigue, cardiotoxicity, increase in depressive symptoms, and reduction in health-related quality of life

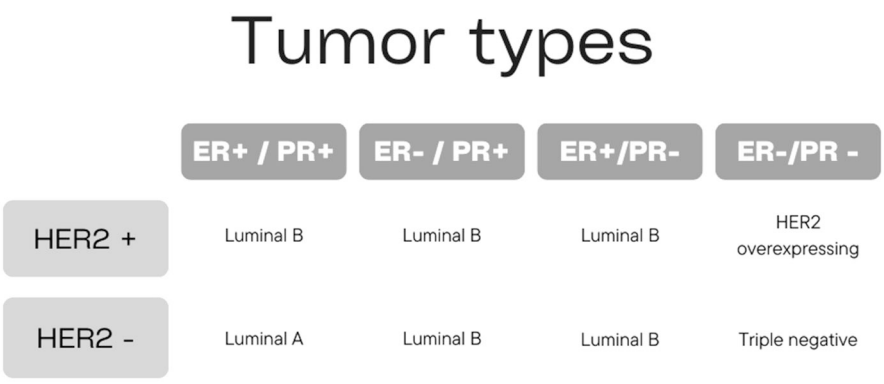

Fig. 1 Breast cancer tumor types. Breast cancer tumor types according to the de European Society for Medical Oncology. *ER* estrogen receptor, *PR* progesterone receptor, *HER2* human epidermal growth factor receptor 2

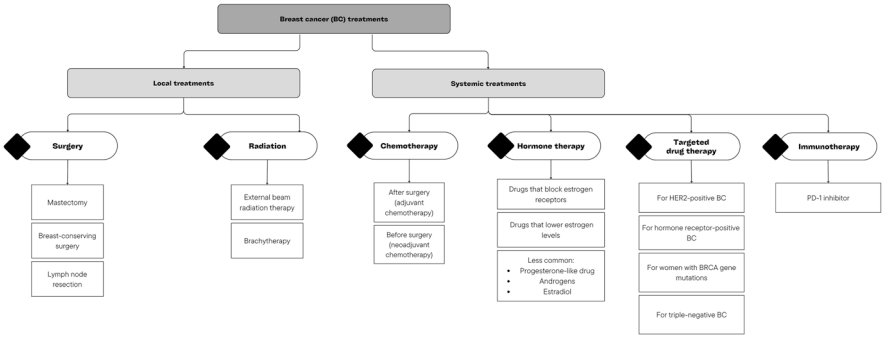

Fig. 2 Breast cancer treatment types. Types of treatment for breast cancer according to the American Cancer Society. *BC* breast cancer, *HER2* human epidermal growth factor receptor 2, *BRCA* breast cancer gene mutations, *PD-1* programmed cell death protein 1

(HRQoL) (European Society for Medical Oncology 2018; American Cancer Society 2021). Focusing on the impact of BC and treatments, several factors are associated with the decrease of HRQoL. Some of these factors are pain and fatigue (Cardoso et al. 2023), perceived physical condition (Fresno-Alba et al. 2023), peripheral neuropathy symptoms (Veiga-Seijo et al. 2023), anxiety (Cardoso et al. 2023), self-esteem (Fresno-Alba et al. 2023), and the fear of disease progression (Cardoso et al. 2023), among others.

The World Health Organization defines quality of life as an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns (World Health Organization). The health-related dimension of quality of life is a multidomain concept that represents the patient's overall perception of the impact of an illness and its treatment (U.S. Department of Health and Human Services FDA Center for Drug Evaluation and Research et al. 2006) and is of utmost importance in daily life as it has a great impact on physical and mental status (Teoli and Bhardwaj 2023). For these reasons, preserving and improving HRQoL in clinical populations is of major clinical and public health relevance.

To assess the extent to which HRQoL is affected by BC and the associated treatments, clinicians and researchers use specialized, validated, and specific, self-reported questionnaires such as the *European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30* (*EORTC QLQ-C30*) (Aaronson et al. 1993), the breast cancer-specific *EORTC QLQ-BR23* (Sprangers et al. 1996), the *Functional Assessment of Cancer Therapy-General (FACT-G)* questionnaire (Cella et al. 1993), and the *Functional Assessment of Cancer Therapy-Breast* (*FACT-B*) questionnaire (Brady et al. 1997). Also, some generic questionnaires are used to assess HRQoL in people with BC, such as the *EuroQoL-5D* (EQ-5D) questionnaire (EuroQoL Group 1990), the *36-Item Short Form Health Survey (SF-36)* (Ware and Sherbourne 1992), and the *12-Item Short Form Health Survey* (*SF-12*) (Ware et al. 1996). All these scales include different HRQoL domains that assess *global*, *physical*, *mental,* and *symptom-related* QoL (Fig. 3).

Physical activity (PA), defined as any bodily movement produced by skeletal muscles that requires energy expenditure, including during leisure time, for transport to get to and from places, or as part of a person's work (World Health Organization 2022), is one of the most recommended nonpharmacological strategies for managing different noncommunicable diseases. Some of the benefits of PA are the improvement and maintenance of physical fitness (including muscular strength, cardiorespiratory fitness, or flexibility) and physical function (World Health Organization 2020). Additionally, PA has shown to prevent, contribute to the management, and improve survival rates in several conditions such as stroke, heart disease, diabetes, hypertension, and different types of cancer (World Health Organization 2020). Physical activity also contributes to maintaining a healthy body weight and improving mental health, physical well-being, and HRQoL (World Health Organization 2020).

Exercise—a subcategory of PA involving planned, structured, repetitive, and purposive PA with the aim of improving or maintaining one or more components of physical fitness (Caspersen et al. 1985)—is widely implemented to achieve the

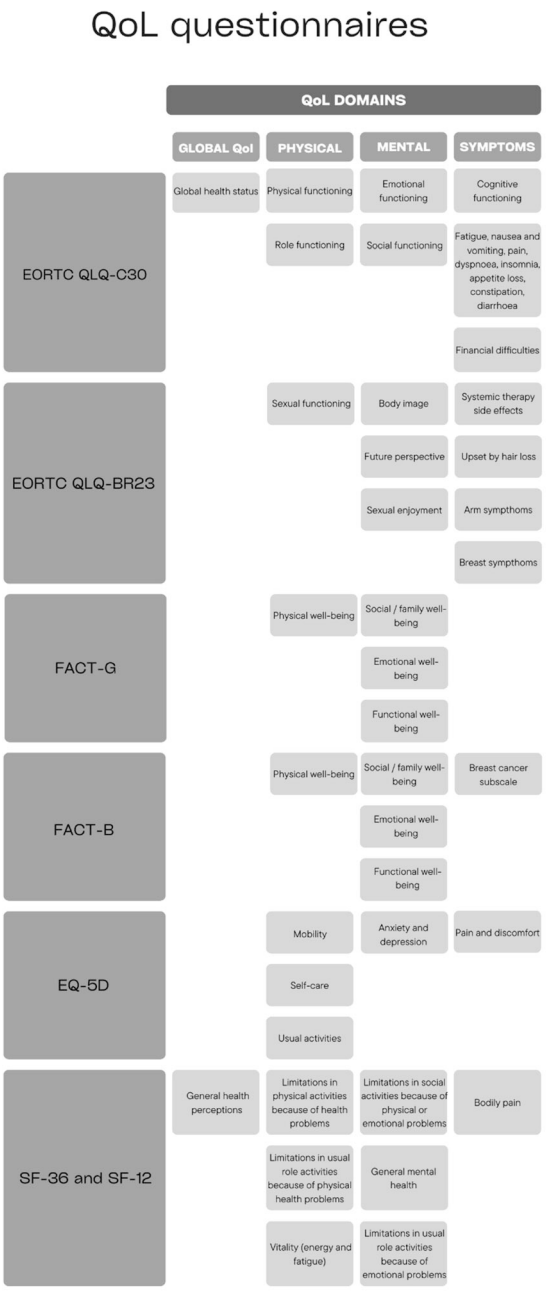

Fig. 3 Health-related quality of life questionnaires. Most used questionnaires to assess health-related quality of life in people living with breast cancer. *QoL* quality of life, *EORTC QLQ-C30* European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30, *EORTC QLQ-BR23* European Organization for Research and Treatment of Cancer Breast Cancer-specific Quality of Life Questionnaire, *FACT-G* Functional Assessment of Cancer Therapy—General questionnaire, *FACT-B* Functional Assessment of Cancer Therapy—Breast questionnaire, *EQ-5D* EuroQoL-5d questionnaire, *SF-36* 36-Item Short Form Health Survey, *SF-12* 12-Item Short Form Health Survey

abovementioned benefits. For these reasons, leading institutions such as the American Cancer Society, the American College of Sports Medicine, and the Exercise and Sports Science Australia—among others—develop detailed exercise

recommendations for people living with BC and BC survivors that are regularly revised and updated. These recommendations include aspects such as intensity, frequency, duration, progression, or type of activity, as well as specific considerations for different side effects. In general, recommendations indicate the need for consulting healthcare providers before initiating an exercise program; the importance of personalizing PA depending on health status, treatment, and individual characteristics; and the importance of exercising gradually. Concerning PA, these recommendations suggest that people with BC should, at least, achieve the current physical activity recommendations for health (i.e., 150 minutes per week of aerobic exercise and twice per week of resistance training) and, ideally, 2–3 days per week for 20–40 min of moderate-intensity aerobic exercise and 2–3 days per week of two-set (8–12 repetitions) moderate to vigorous resistance training (Campbell et al. 2019). Specific recommendations for each side effect are presented in the article by Campbell et al. (2019). In particular, recommendations for improving HRQoL include, on the one hand, 2–3 days per week of supervised aerobic exercise (30 min at 60–80% of maximum heart rate, RPE 11–13) and, on the other hand, 2–3 days per week of resistance training (2–3 sets, 8–15 repetitions, at 60–75% of 1 repetition maximum, RPE 13–15) or a combination of both forms of PA for a higher effectivity (Campbell et al. 2019).

Following these guidelines, several exercise interventions have been conducted to preserve or improve HRQoL in people with BC. Reviewing some general studies, Joaquim et al. (2022) concluded that HRQoL was significantly improved following PA interventions, independently of type and frequency, although medium and longer exercise sessions enhanced the HRQoL of people living with BC, observing higher improvements in those patients engaged in longer-time sessions. Additionally, these authors observed that supervised interventions had more beneficial effects on HRQoL than those unsupervised and that interventions involving more than one exercise type also reported higher improvements. Nevertheless, they also concluded that the improvements did not persist longer than 3 months after the interventions.

Attending to the different dimensions of HRQoL, the meta-analyses by Aune et al. (2022) and Chen et al. (2023a, b) reported that PA interventions resulted in higher *global QoL*, *general health perception* scores, *physical functioning*, *daily life function*, *emotional functioning*, *social function*, and *mental health* scores, although no difference was observed on cognitive function score. Remarkably, Bò et al. (2023) pointed out that evidence regarding the effects of self-managed PA interventions on HRQoL is controversial and highlighted the need for further research. Interestingly, several studies assessed the effectiveness of different PA protocols on HRQoL during systemic treatment, revealing significant improvements for different exercise types (Brownson-Smith et al. 2023).

An in-depth description of different PA (mainly exercise) interventions and their effects on HRQoL in people with BC will now be presented. This review provides an overview of the current evidence on the effectiveness and safety of exercise interventions in this population.

Aerobic Exercise

One of the most common approaches in PA interventions is aerobic exercise, defined as the repetitive and structured physical activity that requires the body's metabolic system to use oxygen to produce energy (Abrams et al. 2013). Some of the benefits of aerobic exercise are lower risk of all-cause mortality, cardiovascular disease, hypertension, type 2 diabetes, different types of cancer, dementia, falls, weight gain, and depression, as well as improved physical function, sleep quality, or HRQoL, among others (U.S. Department of Health and Human Services 2018).

The systematic review by Ficarra et al. (2022) assessed the impact of aerobic exercise and resistance training interventions in BC survivors. As reported by the authors, results showed a 6.8% improvement in HRQoL for those studies implementing aerobic exercise; nevertheless, the authors reported that resistance training interventions showed a higher increase (10.5%). In this line, aimed to improve and maintain HRQoL in BC survivors, Bucciarelli et al. (2023) compared the effects of a 12-week aerobic exercise intervention—consisting of walking or Nordic Walking—with a resistance training intervention. The authors observed improvements in *physical function* (+5 points on average), *pain* (+22 points on average), and *health perception* (+12 points on average) domains of HRQoL only for those participants in the aerobic exercise group, while participants in the resistance training group achieved improvements in *social function* (+12 points on average) and *mental health* (+10 points on average) scales, thus concluding that both aerobic and resistance exercise-induced improvements in HRQoL but showing different response. Nevertheless, the improvements were not maintained during the follow-up. Home-based aerobic exercise interventions have also shown to be effective for BC survivors and are widely implemented. For instance, the home-based aerobic intervention by Farajivafa et al. (2023), consisting of walking, balance exercises, and stretches, reported improvements in *global QoL* (+25 points) and *social functioning* (+16.7 points) in the intervention groups. However, further research is needed to determine the most effective dose and strategies of home-based aerobic exercise to achieve the highest benefits in terms of HRQoL.

Focusing on people with BC undergoing active treatment, the systematic review by Ficarra et al. (2022) assessed the effects of aerobic exercise interventions on HRQoL and suggested an average 4% improvement in HRQoL compared to an average 2.8% decrease in control groups, although it is remarkable that the authors observed a 12.1% increase for those patients involved in studies implementing resistance training. Additionally, Sturgeon et al. (2022) conducted a study aimed to assess the feasibility of a home-based aerobic exercise intervention—using DVD format and an informational binder—in people living with BC receiving neo-adjuvant chemotherapy. The authors concluded that even a 65-minute per week intervention was effective for maintaining *pain*, *physical function,* and *emotional role* scores of HRQoL in this population. Furthermore, Zhu et al. (2023) developed an App aimed to guide patients with BC's home-based aerobic exercise and reported that HRQoL remained stable for all the dimensions of the *FACT-B* questionnaire with a beneficial but not significant trend ($p \geq 0.05$).

Regarding people living with metastatic BC, an aerobic exercise intervention based on the achievement of the daily steps recommendation has shown to be feasible and effective in maintaining HRQoL (−16%, $p = 0.07$) and improving other relevant outcomes such as physical fitness (+7%, $p < 0.001$), muscular strength (+22%, $p < 0.001$), and body composition parameters (BMI, −2.5%, $p = 0.03$; hip circumference, −4%, $p < 0.001$) that might influence HRQoL (Delrieu et al. 2020). Further research involving patients with advanced BC is needed to determine the optimal dosage of aerobic exercise to achieve improvements in HRQoL.

The specific details on the studies implementing aerobic exercise interventions in people with BC during and after treatments are presented in Table 1.

High-Intensity Interval Training

Within aerobic exercise, different configurations are proposed. High-intensity interval training (HIIT) consists of repeated bouts of high-intensity effort followed by varied recovery times (American College of Sports Medicine 2014). Improved body composition, VO2máx., metabolic markers, endothelial function and overall myocardial function, and reduced blood pressure, risk of cardiovascular events, or risk of all-cause mortality are some of the benefits of HIIT (Shiraev and Barclay 2012). For these reasons, HIIT is widely used in daily practice and research studies.

A recent systematic review with meta-analysis by Chen et al. (2023b) concluded that HIIT was superior to usual care in improving *emotional well-being* and fatigue (Chen et al. 2023b) in BC survivors. However, the authors report that the heterogeneous use of assessment tools across studies prevented quantitative synthesis. In this line, Isanejad et al. (2023) compared HIIT to moderate-intensity continuous training and a control group and concluded that participants in the HIIT group achieved higher improvements (as measured by partial eta squared $-\eta^2_p$-, considering small $-\eta^2_p = 0.01$-, medium $-\eta^2_p = 0.06$-, and large $-\eta^2_p = 0.14$- effect) in *social well-being* (effect size: 0.189, $p = 0.026$), *emotional well-being* (effect size: 0.268, $p = 0.017$), *functional well-being* (effect size: 0.209, $p = 0.015$), and *total* (effect size: 0.429, $p = 0.001$) scores of the *FACT-G*. What is more, Schmitt et al. (2016) evaluated whether a short multimodal intervention of 3-week including HIIT may induce further improvements than low-to-moderate intensity training (LMIT) in HRQoL of BC survivors, and contrary to previous researchers, the authors observed that both methods improved HRQoL although LMIT reported higher benefits (as measured by Cohen's *d,* considering small −0.2-, medium −0.5-, and large −0.8- effect) in HRQoL (HIIT: $d = 0.79$, $p < 0.00$; LMIT: $d = 1.14$, $p < 0.00$), *physical functioning* (HIIT: $d = 0.35$, $p = 0.04$; LMIT: $d = 0.89$, $p < 0.00$), *social functioning* (HIIT: $d = -0.08$, $p = 0.33$; LMIT: $d = 0.64$, $p = 0.01$), *emotional functioning* (HIIT: $d = 0.46$, $p = 0.03$; LMIT: $d = 1.25$, $p < 0.00$), *cognitive functioning* (HIIT: $d = 0.31$, $p = 0.07$; LMIT: $d = 0.48$, $p = 0.04$), and *role functioning* (HIIT: $d = 1.04$, $p = 0.01$; LMIT: $d = 1.23$, $p = 0.04$) scales. Results are heterogeneous depending on the HIIT dose, which might suggest that further research is needed to elucidate the optimal dose to improve HRQoL in BC survivors.

Table 1 Detailed information on the studies examining the impact of aerobic exercise and HIIT on health-related quality of life in people living with breast cancer during and after treatments

Authors (year)	Article type	Interventions						HRQoL assessment	Participants	
		PA type	Frequency	Intensity	Time	Duration	Main results		Breast cancer stage	Treatment status
Aerobic exercise										
Bucciarelli et al. (2023)	RCT and 34-month follow-up RCT	IG1: AE (walking) IG2: AE (nordic walking) IG3: RT	IG1: 4 days/week IG2: 3 days/week IG3: 2–3 days/week total of 28 sessions	IG1, IG2, and IG3: week 1–4 RPE 10–11/15, week 5–8 RPE 12–13/15, week 9–12 RPE 13–14	IG1: Weeks 1–4 40 min Weeks 5–12 50 min IG2: 70 min IG3: 50 min	12 weeks	AET: ↑PF, ↑P, ↑HP, =SC, =MH, =RLP, =RLM, =EV RT: ↑SC, ↑MH, =PF, =P, =RLP, =RLM, =EV, =HP"	SF-36	N/A	≥12 months surgery, no chemotherapy, no ongoing radiotherapy
Delrieu et al. (2020)	Single-arm intervention study	IG: Home-based unsupervised walking (n° steps/day)	7 days/week	+1000 steps/day until achieving 10,000 steps/day	N/A	6 months	↓AL, =GH, =PF, =R; =E, =Cog, =SC, =F, =NV, =P, =D, =I, =Con, =Dia, =FD	EORTC QLQ-C30	Stage IV	Undergoing chemotherapy, hormone therapy targeted therapy, and/or radiotherapy

(continued)

Table 1 (continued)

Authors (year)	Article type	Interventions						HRQoL assessment	Participants	
		PA type	Frequency	Intensity	Time	Duration	Main results		Breast cancer stage	Treatment status
Farajivafa et al. (2023)	RCT	IG: walking + balance exercises + stretching exercises CG: UC	Gradually increasing volume from 2 days/week to 3 or 5 days/week	Moderate intensity (being able to converse comfortably during exercise)	Gradually increasing from 15 min/session to: 50–60 min/session (3 days/week) 30–40 min/session (5 days/week)	3 months	↑GH, ↑SF, =PF, =R, =E, =Cog, =F, =NV, =P, =D, =AL, =Con, =Dia, =FD, =BI, =SXF, =SXE, =FP, =STE, =BS, =AS, =UH	EORTC QLQ-C30	Stages I–IIIA	Completed core treatments withing last year
Ficarra et al. (2022)	SR (including RCTs)	Studies conducting RT, continuous AE, combined RT and AE, HIIT, Yoga, or Pilates	1–5 days/week (average: 3 days/week)	AE: 69% VO_{2max}/heart rate reserve RT: 60% 1 RM	N/A	10–48 weeks (average: 22 weeks)	In therapy: AE: IG ↑HRQoL, CG ↓HRQoL Survivors: AE: IG ↑HRQoL, CG ↑HRQoL	EORTC QLQ-C30 EORTC QLQ-BR23 FACT-G FACT-B	Stages I–III	Undergoing therapy or < 5 years from therapy completion
Sturgeon et al. (2022)	RCT	IG: unsupervised AE CG: UC	3 days/week	Weeks 1–4 gradually increasing from 50% VO_{2max} to 60% VO_{2max} Weeks 5–11 gradually increasing from 60% to 80% VO_{2max}	Weeks 1–4: gradually increasing from 60 min/week to ≥75 min/week Week 5–24: ≥75 min/week	16–24 weeks	Comparing IG with CG: ↓P, ↑PF, ↓RLM,	EuroQoL-5D SF-36	Stages I–III	Undergoing chemotherapy

				Week 11 2 days/week at 65–75% VO_{2max} and 1 day/week at ≥80% VO_{2max} Weeks12–24 maintain						
Zhu et al. (2023)	Prepost study	App-based rehabilitation program including nutrition, psychology, AE, and rehabilitation exercises	AE: N/A Rehabilitation exercises: Early stage 3 times/ week Middle stage 3 times/ week Late stage once/day	AE: 60–80% maximum heart rate Rehabilitation exercises: N/A	AE: 20–40 min Rehabilitation exercise: 10–15 min	8–18 weeks	=PS, =SFS, =E, =PF, =AF, =TS	FACT-B	Stages I–III	Completed surgery and undergoing chemotherapy and/or radiotherapy
HIIT										
Bolam et al. (2019)	Two-year follow-up RCT	IG1: RT + HIIT IG2: AE + HIIT CG: UC	2 days/week	RT: 2 sets (8–12 reps) 70–80% 1RM HIIT: 3 × 3 min, RPE 16–18 AE: 20 min moderate intensity continuous AE, RPE 13–15	60 min	16 weeks	Comparing IG1 and IG2 with CG, IG1: ↓GH, ↑PF, ↑E, ↑R, ↓Cog, ↑SC, ↓F, ↓NV, ↓P, ↑D, ↑I, ↓AL, ↓Con, ↑Dia, ↑FD IG2: ↑GH, ↑PF, ↑E, ↑R, ↓Cog, ↑SC, ↓F, ↓NV, ↓P, ↑D, ↑I, ↓AL, ↓Con, ↑Dia, ↓FD	EORTC QLQ-C30	Stages I–IIIa	Undergoing chemotherapy

(continued)

Table 1 (continued)

Authors (year)	Article type	Interventions						HRQoL assessment	Participants	
		PA type	Frequency	Intensity	Time	Duration	Main results		Breast cancer stage	Treatment status
Chen et al. (2023a, b)	SR and MA (including RCTs and pilot RCTs)	Studies conducting HIIT alone, in combination with other types of PA or compared to other types of PA	Average: 2.7 sessions/week	N/A	N/A	6–16 weeks (average: 10.4 weeks)	↑HRQoL, ↑E, ↓An, ↓Dep, ↓SD, ↓IR, ↓PWM, ↑EF	EORTC QLQ-C30 FACT-B	Stages I–III	Two studies: undergoing chemotherapy rest: completed core treatments
Isanejad et al. (2023)	RCT	IG1: HIIT IG2: MICT CG:UC	3 days/week	IG1: warm-up 50–60% VO_{2peak}, main training 4-min bouts 90% VO_{2peak}, 3-min bouts 60% VO_{2peak}, cool-down 50–60% VO_{2peak} IG2: warm-up 50–60% VO_{2peak}, main training 60% VO_{2peak}, cool-down 50–60% VO_{2peak}	IG1: warm-up: 5 min Main training: 4 × 4-min and 3 × 3-min Cool-down: 3 min, total 33 min IG2: warm-up: 5 min Main training: 33 min Cool-down: 3 min, total 41 min	12 weeks	IG1: ↑PF, ↑SC, ↑E, ↑R, ↑TS IG2: ↑PF, ↑SC, ↑E, ↑R, ↑TS CG: ↓PF, ↓SC, ↓E, ↓R, ↓TS	FACT-G	Stages I–III	Undergoing endocrine therapy and have completed chemotherapy and/or radiotherapy

Lee et al. (2021)	RCT	IG: HIIT CG: Less than 30 min/ week of structured exercise	3 days/week	Warm-up 10% peak power output Main training 7 × 1-min 90% peak power output 2-min active recovery 10% peak power output	Warm-up: 5 min Main training: 7 × 1-min followed by 2-min active recovery Total 20 min	8 weeks	↑PF, ↓SC, ↑E, ↑R, ↓BS, ↑TS	FACT-B	Stages I–III	Undergoing adjuvant or neoadjuvant anthracycline-based chemotherapy
Mijwel et al. (2018)	RCT	IG1: RT + HIIT IG2: AE + HIIT CG: UC	2 days/week	RT: 2 sets (8–12 reps) 70%–80% 1RM HIIT: 3 × 3 min, RPE16–18 AE: 20 min moderate intensity continuous AE, RPE 13–15	60 min	16 weeks	Comparing IG1 and IG2 with CG, IG1: =GH, ↑PF, ↑E, ↑R, ↑Cog, =SC, ↓F, =NV, ↓P, =D, ↓I, =AL, =Con, ↑Dia, =FD IG2: =GH, ↑PF, ↑E, ↑R, ↑Cog, =SC, ↓F, =NV, ↓P, =D, ↓I, =AL, =Con, ↑Dia, =FD	EORTC QLQ-C30	Stages I–IIIa	Undergoing chemotherapy
Mijwel et al. (2019)	One-year follow-up RCT	IG1: RT + HIIT IG2: AE + HIIT CG: UC	2 days/week	RT: 2 sets (8–12 reps) 70–80% 1RM HIIT: 3 × 3 min, RPE16–18 AE: 20 min moderate-	60 min	16 weeks	Comparing IG1 and IG2 with CG, IG1: =GH, =PF, =E, =R, =Cog, =SC, =F, =NV, =P,	EORTC QLQ-C30	Stages I–IIIa	Undergoing chemotherapy

(continued)

Table 1 (continued)

Authors (year)	Article type	Interventions						HRQoL assessment	Participants	
		PA type	Frequency	Intensity	Time	Duration	Main results		Breast cancer stage	Treatment status
				intensity continuous AE, RPE 13–15			=D, =I, =AL, =Con, =Dia, =FD IG2: =GH, =PF, ↑E, ↑R, =Cog, =SC, ↓F, =NV, =P, =D, =I, ↓AL, ↓Con, =Dia, =FD			
Schmitt et al. (2016)	RCT	IG1: HIIT CG: Low-to-moderate intensity	3 days/week	IG: warm-up 70% peak heart rate, main training >95% peak heart rate CG: moderate outdoor walking and 60% peak heart rate indoor cycling	IG: Warm-up: 5 min Main training: 8 × 1-min HIIT walking and 2-min slow walking CG: 60 min outdoor walking, 15 min indoor cycling, total 75 min	3 weeks	IG1: ↑GH, ↑PF, ↑E, ↑R, =Cog, =SC, ↓F, =NV, =P, =D, ↓I, =AL, =Con, =Dia, =FD IG2: ↑GH, ↑PF, ↑E, ↑R, ↑Cog, ↑SC, ↓F, =NV, ↓P, ↓D, ↓I, ↓AL, =Con, =Dia, =FD	EORTC QLQ-C30	Stages I–IV	Completed chemotherapy and/or radiotherapy

Schulz et al. (2018)	Prospective cohort pilot study	IG: HIIT + RT CG: UC	2 days/week	HIIT: warm-up 50% VO_{2peak}, main training 85–100% VO_{2peak}, cool-down 50% VO_{2peak} RT: low-intensity sessions 50% 1RM, 2 series, 15 reps more intensive sessions 60–80% 1RM, 2 series, 8–12 reps (2 s concentric, 1 s isometric, 4 s excentric)	HIIT: Warm-up 15 min Main training 10 × 1-min followed by 1-min load-less recovery Cool-down 3 min, total 39 min RT: 30 min	6 weeks	IG: ↓An, ↓Dep CG: =AN, =Dep	HADS	Stages I–III	Undergoing or completed therapy

HIIT high-intensity interval training, *PA* physical activity, *HRQoL* health-related quality of life, *RCT* randomized controlled trial, *IG* intervention group, *PF* physical function, *SC* social function, *MH* mental health, *P* pain, *RLP* role limitation physical, *RLM* role limitation mental, *EV* vital energy, *HP* health perception, *AL* appetite loss, *GH* global health, *R* role, *E* emotional, *Cog* cognitive, *F* fatigue, *NV* nausea and vomiting, *D* dyspnea, *I* insomnia, *Con* constipation, *Dia* diarrhea, *FD* financial difficulties, *CG* control group, *UC* usual care, *RM* repetition maximum, *BI* body image, *SXF* sexual functioning, *SXE* sexual enjoyment, *FP* future perspective, *STE* systemic therapy side effects, *BS* breast symptoms, *AS* arm symptoms, *UH* upset by hair loss, *AE* aerobic exercise, *RT* resistance training, *SR* systematic review, *VO2* oxygen consumption, *PS* physiological status, *SFS* sociofamilial status, *AF* additional focus, *TS* total score, *MA* meta-analysis, *An* anxiety, *Dep* depression, *SD* sadness, *IR* irritation, *PWM* poor working memory, *EF* executive function, *MICT* moderate-intensity continuous training, *HADS* hospital anxiety and depression scale

On the other hand, focusing on people living with BC receiving chemotherapy, Lee et al. (2021) conducted an 8-week HIIT intervention consisting of seven bouts of 1-min high-intensity exercise (90% peak power output) followed by 2-min active recovery (10% peak power output) in a stationary bike. The authors assessed the effects of the intervention on patient-reported outcomes in women with BC receiving anthracycline-based chemotherapy and concluded that HIIT might be an effective approach to maintain all HRQoL domains of the *FACT-B* questionnaire compared to those participants in the control group, who reported a decreased *physical* (−8.7 points on average, $p = 0.04$), *functional* (−8.7 points on average, $p = 0.05$), and *total* (−25.4 points on average, $p = 0.01$) scores of the *FACT-B*. Aimed at finding the most effective HIIT strategy, Mijwel et al. (2018, 2019) compared the effects of adding HIIT protocols to resistance training and aerobic exercise with usual care in patients receiving chemotherapy after the 16-week intervention and at 12-month follow-up. The authors observed that adding HIIT to traditional training methods was effective in improving or maintaining most scales of the EORTC QLQ-C30 compared to usual care in patients undergoing chemotherapy. On the one hand, resistance training + HIIT protocol was superior to aerobic exercise + HIIT compared to usual care after the 16-week intervention (considering small (0.2–0.5), medium (0.6–0.8), and large (>0.8) effect) in *physical functioning* (effect size = 0.49, $p < 0.01$), *role functioning* (effect size = 0.81, $p < 0.01$), *cognitive functioning* (effect size = 0.35, $p = 0.02$), and *fatigue* (effect size = −0.61, $p = 0.01$) scores. On the other hand, at the same time point (16 weeks), aerobic exercise + HIIT was superior to resistance training + HIIT compared to usual care in *emotional functioning* (effect size = 0.40, $p = 0.01$), *pain* (effect size = −0.036, $p = 0.025$), and *insomnia* (effect size = −0.37, $p = 0.04$) scores. The authors also assessed the effects of the intervention at a 12-month follow-up, concluding that only the aerobic exercise + HIIT group experienced improvements in *emotional functioning* (effect size = 0.40, $p = 0.029$), *role functioning* (effect size = 0.33, $p = 0.036$), *fatigue* (effect size = −0.40, $p = 0.041$), *appetite loss* (effect size = −0.66, $p = 0.024$), and *constipation* (effect size = −0.37, $p = 0.019$) scores. In line with previous research, different HIIT configurations report distinct benefits in terms of HRQoL. Nevertheless, the authors reported that these improvements were not maintained in a two-year follow-up (Bolam et al. 2019). Furthermore, Schulz et al. (2018) also explored the effects of adding a HIIT protocol to resistance training compared to a control group who did not exercise. Consistent with previous studies, the authors reported a significant decrease in the anxiety (mean change = −32.9, $p = 0.018$) and depression (−26.9, $p = 0.031$) domains of HRQoL.

Unfortunately, to the best of our knowledge, studies assessing the effects of HIIT interventions on HRQoL in people living with metastatic BC are currently lacking. Considering the potential benefits of HIIT in people with BC during and after active treatment, the absence of studies involving such population highlights the need for conducting this type of intervention or, at least, its feasibility considering this vulnerable population.

The specific details of the studies implementing HIIT interventions in people with BC during and after treatments are presented in Table 1.

Resistance Training

Resistance training is defined as the training aimed to increase power and strength using static, dynamic actions, or both, including all forms of training that involve working against loads greater than usually experienced (Kent 2006). Some of the benefits of resistance training are the enhancement of muscular strength, endurance, and power; the improvement of bone, muscle, and connective tissue growth and durability; the blood glucose regulation; the improvement in aerobic fitness; the management of several health conditions such as diabetes, hypertension, obesity, low back pain, cancer, and cardiovascular diseases; and the amelioration of mental health and HRQoL (Fiatarone Singh et al. 2019).

The impact of resistance training in BC survivors has been described in several studies. The systematic review by Ficarra et al. (2022) reported a mean improvement of 10.5% on HRQoL in BC survivors after resistance training interventions, surpassing the improvements reported after aerobic exercise interventions. In this line, many randomized controlled trials have been conducted to assess the effect of resistance training in different domains of HRQoL. Moraes et al. (2021) implemented an 8-week resistance training program that included exercises for large muscular groups. After the intervention, the authors observed improvements in *physical functioning* (27%, $p = 0.027$), *role functioning* (54%, $p = 0.008$), *emotional role functioning* (42%, $p = 0.027$), and *mental health* (16%, $p = 0.032$) subscales of the SF-36 questionnaire, as well as in *anxiety state* (−19%, $p = 0.012$) and *anxiety trait* (−23%, $p = 0.001$) compared to participants in the control group. Additionally, the study by Hagstrom et al. (2016), who implemented a 16-week supervised resistance training intervention, showed that the resistance training group improved HRQoL by 6.9 points compared to 1.6 points for the control group. Also, Calonego et al. (2023) concluded that HRQoL was significantly improved after a resistance training intervention independently of the set configuration: simple-set group participants reported a 4.3% improvement, and multiple-set group participants reported a 7.9% improvement with no differences between groups. The study by García-Soidán et al. (2020) compared the effect of three different types of PA interventions on HRQoL in BC survivors and observed that participants in the resistance training group showed improvements in all the items of the SF-12 questionnaire, while the other intervention types reported improvements only in various domains, thus concluding that people with BC should include predominantly strength exercises in their PA routine. In this line, the trial by Lin et al. (2023) compared the effects of three different PA interventions on HRQoL, pain, and lymphedema in BC survivors. The results suggest that the group performing progressive resistance training + joint mobility exercises obtained the highest improvements in HRQoL (change in HRQoL = 13.032, $p = 0.008$) compared to groups who performed joint mobility alone or joint mobility + aerobic exercise. However, some studies as the randomized trial by Soriano-Maldonado et al. (2023) observed no improvements but maintenance of HRQoL (Cohen's $d = 0.30$, $p = 0.245$) after a resistance training intervention, underlining the relevance of determining the adequate resistance training dosage for improving HRQoL in BC survivors.

Regarding people living with BC receiving adjuvant therapy, the review by Gerland et al. (2021) summarized the results of eight randomized controlled trials assessing the effects of different configurations of resistance training interventions. The authors concluded that resistance training induced beneficial effects on HRQoL, showing improvements or maintenance of HRQoL. Both low- and high-intensity resistance training showed beneficial effects on HRQoL (Gerland et al. 2021). Additionally, the systematic review by Ficarra et al. (2022) concluded that resistance training induced a 12.1% improvement in HRQoL after the interventions compared to a −2.4% decrease in control groups.

Considering patients with metastatic BC, literature is scarce. Nevertheless, some randomized trials have been conducted. For instance, Yee et al. (2019) conducted an 8-week pilot study to assess the effects of a resistance training program consisting of seven exercises for large muscle groups. The authors reported benefits in favor of the intervention group in all subscales of the EORTC QLQ-C30 (effect size calculated using Glass's delta, considering small (<0.2), medium (0.5), and large (>0.8) effect (effect sizes = 0.04–1.71, all $p < 0.05$).

The specific details of the studies implementing resistance training interventions in people with BC during and after treatments are presented in Table 2.

Aerobic Exercise Combined with Resistance Training

Several studies have also combined both aerobic exercise programs with resistance training to enhance HRQoL, which receives the denomination of concurrent training. A summary of the results of our review on this topic is presented below.

A recent network meta-analysis by Wang et al. (2023) compared the effectiveness of different exercise-based interventions that included aerobic exercise, resistance training, concurrent training, and yoga and concluded that concurrent training was the most effective (presenting effect sizes as point estimates) type of intervention in improving HRQoL in BC survivors (effect size = 1.31; 95% confidence interval (CI): 0.49, 2.12) compared to aerobic (effect size = 0.83; 95% CI: 0.03, 1.63), yoga (effect size = 0.63; 95% CI: −0.67, 1.92), and strength (effect size = 0.19; 95% CI: −1.08, 1.46) when compared to the control group (usual care). Furthermore, the meta-analysis by Aune et al. (2022) conducted subgroup analyses depending on the PA intervention type and reported that strong effects on HRQoL were observed for combined aerobic and resistance training, whereas intermediate effects were observed for resistance training and aerobic exercise separately. Attending to depression and anxiety, the systematic review of reviews by Lake et al. (2022) presented the meta-analysis by Singh et al. (2018), who observed significant reductions only for those participants in the concurrent training groups (depression: standardized mean difference = 0.62; 95% CI: 0.18, 1.06; anxiety: standardized mean difference: 1.36; 95% CI: 1.10, 1.62). In line with these authors, Kendall et al. (2023) conducted a pilot study implementing a concurrent training intervention, reporting medium and small improvements in depression (Cohen's $d = -0.43$), *physical well-being* (Cohen's $d = 0.30$), and *overall QoL*

Table 2 Detailed information on the studies examining the impact of resistance training and concurrent training on health-related quality of life in people living with breast cancer during and after treatments

Authors (year)	Article type	Interventions						HRQoL assessment	Participants	
		PA type	Frequency	Intensity	Time	Duration	Main results		Breast cancer stage	Treatment status
Resistance training										
Ficarra et al. (2022)	SR (including RCTs)	Studies conducting RT, continuous AE, combined RT and AE, HIIT, Yog, or Pilates	1–5 days/ week (average: 3 days/ week)	AE: 69% VO_{2max}/heart rate reserve RT: 60% 1 RM	N/A	10–48 weeks (average: 22 weeks)	In therapy: RT: IG ↑HRQoL, CG ↓HRQoL BC survivors: RT: IG ↑HRQoL, CG ↑HRQoL	EORTC QLQ-C30 EORTC QLQ-BR23 FACT-G FACT-B	Stages I–III	Undergoing therapy or <5 years from therapy completion
García-Soidán et al. (2020)	RCT	IG1: RT IG2: AQ IG3: AE CG: UC	2 days/ week	IG1: Weeks 1–6: 2 sets (12 reps) at 50–60% 1RM Weeks 7–8: 2 sets (20 reps) at 60% 1RM Weeks 9–12: 3 sets (10 reps) at 60–80% 1RM IG2: Weeks 1–2: low intensity	IG1: 55-60 min IG2: 55 min IG3: 55 min	2 years (45 weeks/ year)	IG1: ↑PF, ↓RLP, ↓P, ↑GH, ↓EV, ↓RLM, ↑SC, ↑MH, ↑PC, ↑MC IG2: ↑PF, ↓RLP, ↓P, ↑GH, ↑EV, ↓RLM, ↑SC, =MH, ↑PC, ↑MC IG3: ↑PF, ↑RLP, ↑P, ↑GH, ↓EV, ↓RLM, ↑SC,	SF-12	N/A	Completed surgery and > 6 months from chemotherapy completion

(continued)

Table 2 (continued)

Authors (year)	Article type	Interventions						HRQoL assessment	Participants	
		PA type	Frequency	Intensity	Time	Duration	Main results		Breast cancer stage	Treatment status
				Weeks 3–12: gradually increasing intensity IG3: N/A			↓MH, ↑PC, ↑MC			
Gerland et al. (2021)	Narrative review	RT	1–7 days/ week	40–90% 1RM/5 METs/13–15 RPE	N/A	8–96 weeks	Acute therapy: ↑HRQoL BC survivors: ↑HRQoL	EORTC QLQ-C30 EORTC QLQ-BR23 FACT-G FACT-B	Stages I–IV	Patients undergoing acute treatment and after completion
Hagstrom et al. (2016)	RCT	IG: RT CG:UC	3 days/ week	Based on the 8RM	60 min	16 weeks	↑TS, =E, =R, =SC, ↑PF	FACT-G	Stages I–IIIA	Completed surgery, chemotherapy, and/or radiotherapy
Lin et al. (2023)	RCT	IG1: joint mobility exercises + intensive follow-up IG2: joint mobility exercises + AE + intensive follow-up IG3: joint mobility exercises +	Joint mobility exercise: 3 times/ day AE: 5 days/ week RT: 2–3 days/ week	Joint mobility exercise: 60–80% maximum heart rate AE: 60–80% maximum heart rate RT: gradually increasing from 50% 1RM	Joint mobility exercise: 15 min AE: 35 min RT: N/A	6 months	↑HRQoL	FACT-B	N/A	Completed surgery

		RT + intensive follow-up								
Moraes et al. (2021)	RCT	IG: RT CG:UC	1 day/ week	3 sets until volitional failure (8–12 RM). Legged dead lifts and sit-ups: 8–12 reps with submaximal loads. Abdominal exercise: 20 reps.	N/A	8 weeks	=PF, ↓RLP, =P, =GH, =EV, =SC, ↑E, =MH	SF-36	N/A	Completed surgery, chemotherapy and/or radiotherapy
Soriano-Maldonado et al. (2023)	RCT	IG: RT + unsupervised home-based AE CG: unsupervised home-based AE	2 days/ week	Weeks 1–2: 40% 1RM Weeks 3–5: 50% 1RM Weeks 6–8: 55% 1RM Weeks 9–11: 60% 1RM Week 12: 70% 1RM	60 min	12 weeks	=HRQoL	FACT-B	Stages I–III	Completed surgery, chemotherapy and/or radiotherapy
Yee et al. (2019)	Pilot RCT	IG: RT + unsupervised home-based AE CG: UC	2 days/ week	Walking: 11–13 RPE RT: 2 sets (10–12 reps) at 6–7/10 RPE	40–55 min	8 weeks	↑GH, ↑PF, ↑E, ↑R, ↓Cog, ↑SC, ↓F, ↑NV, ↓P, ↓D, ↓I, =AL, ↑Con, ↑Dia, ↓FD	EORTC QLQ-C30	Stage IV	Undergoing or completed treatment
Combined AE and RT										
Andersen et al. (2022)	SR and MA (inclu-ding RCTs)	Studies conducting AE, RT, combined	1–7 days/ week	AE: 11–18 RPE/60–70 maximum	AE: 20–250 min/ week	6 weeks—1 year	↑HRQoL	EORTC QLQC30 FACT-B	Stages I–IV	At least 50% of the participants receiving

(continued)

Table 2 (continued)

Authors (year)	Article type	Interventions						HRQoL assessment	Participants	
		PA type	Frequency	Intensity	Time	Duration	Main results		Breast cancer stage	Treatment status
		RT and AE or other complementary and alternative medicine		aerobic power/ 50–85% maximum heart rate / 50–85% heart rate reserve/40–75% VO_{2max} RT: 40–80% 1RM/3–20 RPE	RT: 20–180 min/ week			FACT-G SF-36 WHOQoL-BREF CARES-SF FACT-AN		systemic treatment regardless of radiotherapy and/or surgery type
Aune et al. (2022)	SR and MA (including RCTs)	Studies conducting AE, RT, combined RT and AE, or other complementary and alternative medicine	1–7 days/ week	Low to high intensity	10–90 min/ session	3–48 weeks	↑GH, ↑PF, ↑PC, ↑E, ↑MH, =MC	EORTC QLQ-C30 FACT-G FACT-B SF-36	Stages I–IV	Undergoing or completed treatment
Kendall et al. (2023)	Implementation-effectiveness trial	AE + RT + balance + flexibility	2 days/ week	N/A	90–120 min/ week	12 weeks	↑PF, =SC, =E, =R, ↑F, ↑TS	FACT-G	Stages I–IV	Undergoing or completed treatment
Mavropalias et al. (2023)	RCT	IG: AE + RT CG: UC	AE: 5 days/ week RT: 2–3 days/ week	12–13 RPE	AE: 60–150 min/ week RT: N/A	12 weeks	↑HRQoL at week 6, =HRQoL at week 12	FACT-B	Stages I–III	Weeks 1–6 undergoing radiotherapy Weeks 7–12 completed radiotherapy
Sheean et al. (2021)	RCT	IG: behavioral intervention addressing adoption of	AE: 5–7 days/ week RT:	Moderate intensity	AE: 150 min/ week RT: N/A	12 weeks	↑TS, ↑PF, ↑E, =SC, =R, ↑BS, ↑ES, =F	FACT-B	Stage IV	Undergoing active treatment

		nutrition and PA guidelines CG: UC	2 days/ Week							
Singh et al. (2018)	SR and MA (including RCTs)	Studies conducting AE, RT, combined RT and AE, or others	1–7 days/ week	AE: 7–8/10 RPE/40–75% VO_{2max}/ 55–75% VO_{2peak}/ 55–85% maximum heart rate/40–65% heart rate reserve RT: 40–90% 1RM/4–7/10 RPE	15–90 min	6 weeks—12 months	↑HRQoL	EORTC QLQ-C30 FACT-G FACT-B FACT-AN SF-36 functional living index of cancer Lymphedema QoL scale QOL-BC	Stages II–IV	Undergoing or completed treatment
Wang et al. (2023)	Network MA (including RCTs)	Studies conducting AE, RT, combined RT and AE, or yoga	1–7 days/ week	3–6/10 RPE / 40–59% heart rate reserve/ 60–80% maximum heart rate/low-high intensity/ 40–70% 1RM	15–90 min	12 weeks	↑HRQoL	EORTC QLQ-C30 FACT-B IBCSG QoL	Stages I–III	Undergoing or completed treatment

HIIT high-intensity interval training, *PA* physical activity, *RT* resistance training, *SR* systematic review, *HRQoL* health-related quality of life, *RCT* randomized controlled trial, *IG* intervention group, *AE* aerobic exercise, *AQ* aquatic exercise, *RM* repetition maximum, *PF* physical function, *SC* social function, *MH* mental health, *P* pain, *RLP* role limitation physical, *RLM* role limitation mental, *EV* vital energy, *HP* health perception, *AL* appetite loss, *GH* global health, *R* role, *E* emotional, *Cog* cognitive, *F* fatigue, *NV* nausea and vomiting, *D* dyspnea, *I* insomnia, *Con* constipation, *Dia* diarrhea, *FD* financial difficulties, *CG* control group, *UC* usual care, *MC* SF-12 mental component, *PC* SF-12 physical component, *BI* body image, *SXF* sexual functioning, *SXE* sexual enjoyment, *FP* future perspective, *STE* systemic therapy side effects, *BS* breast symptoms, *ES* endocrine symptoms, *AS* arm symptoms, *UH* upset by hair loss, *VO2* oxygen consumption, *PS* physiological status, *SFS* sociofamilial status, *AF* additional focus, *TS* total score, *MA* meta-analysis, *MET* one metabolic equivalent, *RPE* rate of perceived exertion, *An* anxiety, *Dep* depression, *SD* sadness, *IR* irritation, *PWM* poor working memory, *EF* executive function, *MICT* moderate-intensity continuous training, *HADS* hospital anxiety and depression scale, *CARES-SF* cancer rehabilitation evaluation system–short form, *WHOQOL-BREF* World Health Organization quality of life—short form, *FACT-AN* functional assessment of cancer therapy—anemia, *QOL-B* quality of life instrument—breast cancer patient version, *IBCSG QoL* international breast cancer study group quality of life

(Cohen's $d = 0.12$) (all $p < 0.05$), pointing out positive trends in social, *emotional*, and *functional well-being* after the intervention.

On the other hand, studies including people with BC receiving systemic treatment have also been conducted. The meta-analysis by Andersen et al. (2022) compared the effectiveness of different types, extensiveness, and delivery modes of PA interventions and concluded that all the intervention types showed improvements in HRQoL and *physical function.* However, the authors highlighted that the physical activity type had little influence on the effects of the intervention, although concurrent training reported higher improvements (as measured by standardized mean differences, considering small (0.2), medium (0.5), and large (0.8) effects) in HRQoL (effect size = 0.57; 95% CI: 0.36, 0.78) and *physical function* (effect size = 0.82; 95% CI: 0.58, 1.06). In patients undergoing radiotherapy, Mavropalias et al. (2023) observed improvements in HRQoL and fatigue, although the authors did not report the effect sizes or mean changes. Nevertheless, the authors challenge the dosage of current recommendations, suggesting that people living with BC might achieve similar improvements in HRQoL with smaller dosages of PA.

Regarding patients with metastatic BC, existing evidence is not extensive, although several trials have been conducted. In this line, Sheean et al. (2021) conducted a 12-week pilot study combining aerobic exercise and resistance training, observing differences in favor of the intervention group in *general QoL* (6.2 vs. 1.8, $p = 0.003$), *physical well-being* (2.7 vs. 0.7, $p = 0.009$), *emotional well-being* (2.1 vs. 0.9, $p = 0.020$), *breast cancer* (13.2 vs. 2.1, $p = 0.001$), and *endocrine symptoms* (17.7 vs. 2.1, $p = 0.007$) subscales of the *FACT-B* questionnaire compared to the control group, therefore suggesting that aerobic exercise combined with resistance training is also beneficial for that people with stage IV BC.

The specific details of the studies implementing aerobic exercise combined with resistance training interventions in people with BC during and after treatments are presented in Table 2.

Mind-Body Interventions

Besides the abovementioned PA perspectives, many interventions are composed of other typology of activities. Mind-body interventions need for special consideration. This approach focuses on the communication between mind and body and the powerful ways in which emotional, mental, social, and spiritual factors can directly affect health (Rice 2001). Tai Chi Chuan, Baduanjin, and yoga are three of the most commonly practiced forms of mind-body interventions, and some of their benefits are the amelioration of low-back or osteoarthritis-related pain, balance, stability, anxiety, depression, or HRQoL (National Center for Complementary and Integrative Health 2021). Particularly in people living with BC and BC survivors, mind-body interventions have shown numerous beneficial effects, also in HRQoL.

The systematic review with meta-analysis by Li et al. (2023) assessed the effects of Tai Chi Chuan training in people living with BC and BC survivors (not including people living with stage IV BC). The authors reported beneficial effects on HRQoL

(standardized mean difference = 0.35; 95% CI: 0.15, 0.55), showing no moderating effect by duration and frequency. In this regard, the systematic review with meta-analysis by Gong et al. (2022) aimed to determine the effects of Baduanjin exercise in patients with BC (not including patients with metastatic BC) and showed improvements in *emotional well-being* (standardized mean difference = 0.67; 95% CI, 0.26–1.07; p = 0.001), *functional well-being* (standardized mean difference = 0.55; 95% CI, 0.30–0.79; p < 0.00001), *breast cancer subscale* (standardized mean difference = 0.39; 95% CI, 0.02–0.77; p = 0.04), anxiety (standardized mean difference = −0.60; 95% CI, −1.15 to −0.05; p = 0.03), depression (standardized mean difference = −0.70 95% CI, −0.97 to −0.42; p < 0.00001), as well as in *total QoL* (standardized mean difference = 0.83; 95% CI, 0.58–1.08; p < 0.00001) scores. Similarly, yoga-based interventions have reported beneficial effects on HRQoL in people with BC. The systematic review with meta-analysis by Hsueh et al. (2021) assessed the effects of yoga-based interventions in people living with BC (including all cancer stages and treatment status) and revealed significant improvements in *social well-being* (weighted mean difference = 1.36; 95% CI, 0.12–2.61; p = 0.03), *emotional well-being* (weighted mean difference = 1.46; 95% CI, 0.26–2.66; p = 0.02), and *functional well-being* (weighted mean difference = 2.04; 95% CI, 0.21–3.87, p = 0.03) domains of HRQoL.

Overall, mind-body interventions are considered a safe approach to effectively improve HRQoL in people with BC, although other PA configurations might report greater improvements (Wang et al. 2023). The specific details of the studies implementing mind-body interventions in people with BC during and after treatments are presented in Table 3.

Aquatic Exercise

Exercise intervention designs are varied and include many different types of activities following diverse strategies. Aquatic exercises are commonly considered for clinical populations due to their benefits on strength, cardiorespiratory fitness, balance, flexibility, pain, anthropometry, and HRQoL (Faíl et al. 2022). For these reasons, Aquatic exercise interventions are used with people living with BC.

In this line, the meta-analysis by Wang et al. (2022) aimed to explore whether aquatic exercise affected the rehabilitation process of BC survivors and showed significant improvements in HRQoL (mean difference = 2.85; 95% CI, 0.62, 5.09, p = 0.01) after water-based exercise interventions. As well, the review by Mur-Gimeno et al. (2022) reported beneficial effects of aquatic exercise interventions; however, the improvements were not maintained in the 6-month follow-up. What is more, Maccarone et al. (2023) conducted a scoping review to assess the effect of water-based interventions in patients with lymphedema and observed improvements in HRQoL among other benefits such as satisfaction and adherence to treatment compared with conventional approaches. Nevertheless, when comparing the effects of a 2-year intervention consisting of aquatic exercise, aerobic exercise, resistance training, or a control group, García-Soidán et al. (2020) observed

Table 3 Detailed information on the studies examining the impact of mind-body interventions, aquatic exercises, and exercise plus dietary interventions on health-related quality of life in people living with breast cancer during and after treatments

Authors (year)	Article type	Interventions						HRQoL assessment	Participants	
		PA type	Frequency	Intensity	Time	Duration	Main results		Breast cancer stage	Treatment status
Mind-body interventions										
Gong et al. (2022)	SR and MA (including RCTs)	Baduanjin	2–7 days/ week	N/A	20–90 min	8–24 weeks	↑TS, =PF, =SC, ↑E, ↑R, ↓BS	FACT-B SF-36 EORTC QLQ-C30 FACT-G	Stages I–III	Completed treatments
Hsueh et al. (2021)	SR and MA (including RCTs)	Yoga	1–7 days/ week	N/A	60–120 min	1–12 weeks	=PF, ↑SC, ↑E, ↑R	FACT-G FACT-B EORTC QLQ-C30 SF-36 SF-12	Stages 0–IV	Undergoing or completed treatments
Li et al. (2023)	SR and MA (including RCTs)	Tai Chi Chuan	3–14 sessions/ week	N/A	20–60 min	12–24 weeks	↑HRQoL	SF-36 WHOQOL-BREF FACT-B FACIT-F	Stages 0–III	Undergoing or completed treatments
Wang et al. (2023)	Network MA (including RCTs)	Studies conducting AE, RT, combined RT and AE, or yoga	1–7 days/ week	3–6/10 RPE/40–59% heart rate reserve/ 60–80% maximum heart rate/low-high intensity/ 40–70% 1RM	15–90 min	12 weeks	↑HRQoL	EORTC QLQ-C30 FACT-B IBCSG QoL	Stages I–III	Undergoing or completed treatment
Aquatic exercise										
García-Soidán et al. (2020)	RCT	IG1: RT IG2: AQ IG3: AE CG: UC	2 days/ week	IG1: Week 1–6 2 sets (12 reps) at 50–60% 1RM Week 7–8	IG1: 55-60 min IG2: 55 min IG3: 55 min	2 years (45 weeks/ year)	IG1: ↑PF, ↓RLP, ↓P, ↑GH, ↓EV, ↓RLM, ↑SC, ↑MH, ↑PC, ↑MC IG2: ↑PF, ↓RLP, ↓P, ↑GH, ↑EV,	SF-12	N/A	Completed surgery and >6 months from chemotherapy completion

				2 sets (20 reps) at 60% 1RM Weeks 9–12 3 series (10 reps) at 60–80 and 1RM IG2: Weeks 1–2 low intensity Week 3–12 gradually increasing intensity IG3: N/A			↓RLM, ↑SC, =MH, ↑PC, ↑MC IG3: ↑PF, ↑RLP, ↑P, ↑GH, ↓EV, ↓RLM, ↑SC, ↓MH, ↑PC, ↑MC			
Maccarone et al. (2023)	Scoping review	AQ	1–3 days/ week	Low-moderate intensity	30–60 min	6–12 weeks	↑HRQoL	27-item upper limb lymphedemaquestionnaire SF-36 Lymphedema QoL questionnaire	N/A	N/A
Mur-Gimeno et al. (2022)	SR	AQ, AE, RT, core stability, stretching, mobility, breathing exercises, recovery strategies, visualization techniques, or lymph node massage	1–3 days/ week	Low-vigorous intensity	30–60 min	8–48 weeks	↑HRQoL	N/A	N/A	N/A
Wang et al. (2022)	SR and MA (including RCTs)	AQ, land-based exercises, or UC	3 days/ week	N/A	60 min	8 weeks–1 year	↑HRQoL	SF-12 FACT-B EuroQoL	Stages I–IIIA	Completed adjuvant treatment

(continued)

Table 3 (continued)

Authors (year)	Article type	Interventions						HRQoL assessment	Participants	
		PA type	Frequency	Intensity	Time	Duration	Main results		Breast cancer stage	Treatment status
Exercise plus diet										
Pérez-Bilbao et al. (2023)	SR	AE or combined RT and AE + diet RT or combined RT and AE + supplementation	2–> 5 days/ week	Assessed through RPE, heart rate reserve, and peak heart rate, %1RM	Interventions including diet: 30–45 min Interventions including supplementation: 20–60 min	10 weeks–24 months	Interventions including diet: ↑HRQoL Interventions including supplementation: N/A	EORTC QLQ-C30 EORTC QLQ-BR23 FACT-B	Stages 0–IV	Undergoing or completed treatment

HIIT high-intensity interval training, *PA* physical activity, *HRQoL* health-related quality of life, *RCT* randomized controlled trial, *IG* intervention group, *CG* control group, *UC* usual care, *AE* aerobic exercise, *RT* resistance training, *SR* systematic review, *MA* meta-analysis, *VO2* oxygen consumption, *MICT* moderate-intensity continuous training, *HADS* hospital anxiety and depression scale, *WHOQOL-BREF* World Health Organization quality of life—short form, *IBCSG QoL* international breast cancer study group quality of life, *AQ* aquatic exercise, *PF* physical function, *RLP* role limitation physical, *P* pain, *GH* global health, *EV* vital energy, *RLM* role limitation mental, *SC* social, *MH* mental health, *PC* SF-12 physical component, *MC* SF-12 mental component

that resistance training was superior to other groups in almost all the studied variables, including several domains of HRQoL such as *emotional limitations*(−14.6 points, $p < 0.0001$), *social functioning* (32.6 points, $p < 0.0001$), *mental health* (9.5 points, $p < 0.0001$), and the *mental components* (5.6 points, $p < 0.0001$) of the SF-12. On the other hand, the aquatic exercise group was superior in *physical functioning* (3.2 points, $p < 0.01$), *physical limitations* (−4.7 points, $p < 0.0001$), *vitality* (3.3 points, $p < 0.01$), *pain* (−2.3 points, $p < 0.01$), and the *physical component* (2.7 points, $p < 0.01$) of the SF-12. In this study, the authors concluded that BC survivors should mainly implement resistance training to improve HRQoL, although aquatic exercise might be a beneficial strategy to increase weekly PA.

Many interventions have been developed for BC survivors. However, information about aquatic exercise interventions including people with BC undergoing active treatment is scarce and unclear. The specific details of the studies implementing aquatic exercise interventions in people with BC during and after treatments are presented in Table 3.

Exercise and Dietary Interventions

Current evidence support the high beneficial effect of exercise interventions alone on HRQoL in people with BC during and after the treatments. However, multimodal interventions including exercise and diet are also widely implemented and have been proved to be effective for improving patient-related outcomes, including HRQoL. The systematic review by Pérez-Bilbao et al. (2023) assessed the effects of exercise plus diet and PA plus supplementation on HRQoL in people with BC during and after treatments (remarkably, only one study included people living with metastatic BC). The authors observed improvements in *global QoL* and *physical*, *role*, *emotional*, *cognitive*, and *social function* domains of the EORTC QLE-C30 questionnaire (+42.7% on average). In those studies using the *FACT-B* questionnaire, the authors found benefits in the *emotional well-being,* the *breast cancer* subscales, and the *FACT-B* total score (+15.1% on average). However, the authors highlight that significant decreases in *sexual function* and *sexual enjoyment* subscales were found. Pérez-Bilbao et al. (2023) suggest that a combined approach of aerobic exercise and resistance training combined with a nutritional intervention might be the most effective for improving HRQoL in people with BC during and after treatments. The specific details of the studies implementing exercise plus diet interventions in people with BC during and after treatments are presented in Table 3.

Conclusion

Physical activity is highly beneficial in people with BC during and after the treatments. This chapter summarizes the current PA guidelines for individuals with BC and presents an overview of different types of PA (mostly exercise) interventions that have shown to be effective in maintaining and improving HRQoL in people with BC

during and after the treatments. The current body of evidence indicates that aerobic exercise, resistance training, high-intensity interval training, the combination of aerobic and resistance training, mind-body interventions, and exercise combined with diet improve HRQoL in people with BC. However, the benefits of exercise on HRQoL are not maintained when exercise is discontinued, suggesting that PA/exercise should become a daily routine for people with BC and BC survivors to produce sustained improvements in HRQoL.

Depending on the aim of the intervention, different exercise configurations might be considered. Remarkably, the disease stage and treatment status should be considered to precisely prescribe exercise. The current evidence suggests that concurrent training (i.e., aerobic exercise plus resistance training) induces the highest benefits on HRQoL in people living with BC during and after the treatments. Nevertheless, including mind-body (ideally) or aquatic exercise should be considered to enhance those improvements. Notably, multicomponent (including nutritional) interventions should also be considered, when possible, to optimize the results.

On the basis of the current evidence and the characteristics of the exercise interventions conducted to date (see Tables 1, 2, and 3), a number of general suggestions can be proposed to enhance HRQoL in people with BC during the treatments and in BC survivors. These suggestions can be considered by exercise professionals or other healthcare providers to undertake exercise interventions in this population. Attending to aerobic exercise, the interventions conducted to date included the weekly frequency ranging from 1 to 7 days per week, a volume ranging from 15 to $\geq$75 min, and an intensity ranging from 50% to $\geq$80% VO_{2max} or 10–15 units in the rating of perceived exertion scale (RPE) (Borg 1998). Regarding HIIT, the interventions conducted to date included a weekly frequency ranging from 2 to 3 days per week, a volume ranging from 20 to 39 min, and an intensity ranging from 50% to 100% VO_{2peak}, 70–>95% of the maximum heart rate, 10–90% of the peak power output, or 16–18 RPE. Regarding resistance training, the interventions conducted to date included a weekly frequency ranging from 1 to 7 days per week, a volume ranging from 2 to 3 sets of 8–20 repetitions, a duration of 40 to 60 minutes, and an intensity ranging from 40–90% of the one repetition maximum or 6–15 RPE. The mind-body interventions included a weekly frequency ranging from 1 to 7 days per week and a volume ranging from 15 to 120 min. Finally, the aquatic exercise interventions undertook a weekly frequency ranging from 1 to 3 days per week, a volume ranging from 30 to 60 min, and an intensity ranging from low to vigorous without further specifications.

It must also be considered that the evidence assessing the effects of exercise interventions on HRQoL in people with stage IV BC is insufficient and the quality of the studies is scarce. The scientific community might consider that people with metastatic BC—whose HRQoL decreases as the disease progresses—should also be able to participate in accurate and evidence-based PA programs to improve or at least maintain their HRQoL. Consequently, although growing evidence supports the benefits of exercise on HRQoL, further research is imperative to extend the evidence on the benefits of PA to all individuals with BC.

Applications to Other Diseases

Leading institutions are highly recommending PA for clinical populations (Erickson et al. 2019; Kraus et al. 2019; Pescatello et al. 2019; Kanaley et al. 2022). Numerous interventions have been conducted in patients with cardiovascular, metabolic, respiratory, rheumatic, cognitive, or mental diseases or disorders—among others—resulting in high benefits in terms of cardiorespiratory fitness, body composition, muscular strength, physical function, bone health, hormonal balance, pain management, self-esteem, depression, or anxiety (Anderson et al. 2016; Kraus et al. 2019; Yang et al. 2022; Blaess et al. 2023; Méndez-Aguado et al. 2023), thus leading to reduced morbidity and mortality risks and increased HRQoL (Kraus et al. 2019).

Focusing on people with or at risk of cardiovascular and metabolic diseases, PA—and especially HIIT—interventions have reported improvements in different domains of HRQoL although the maintenance at follow-up remains unclear (Anderson et al. 2016). What is more, the meta-analysis by Su et al. (2020) assessed the effects of eHealth cardiac rehabilitation interventions and observed improvements in HRQoL. Even educational interventions including exercise advice show benefits in HRQoL for cardiac patients (Feng et al. 2021).

Regarding people suffering from rheumatic diseases, the systematic umbrella review by Kraus et al. (2019) observed increases on HRQoL in people living with hip and knee osteoarthritis after PA interventions independently of the exercise mode (resistance training, aerobic exercise, Tai Chi, etc.). In this line, patients with lupus also benefit from PA interventions (including aerobic exercise and/or resistance training), reporting significant improvements in HRQoL (Blaess et al. 2023; Da Hora et al. 2019).

Considering people with cognitive disorders, the meta-analysis by Hong et al. (2024) showed large effects on HRQoL after multitask interventions including aerobic exercise, resistance training, mobility games, or balance exercises. Depression and anxiety also reported improvements after different PA interventions, according to the network meta-analysis by Yang et al. (2022). Interestingly, exergaming interventions reported promising effects on HRQoL in people with cognitive disorders (Swinnen et al. (2020).

People living with mental disorders have also benefited from PA interventions. Current evidence suggests that diverse PA interventions implementing aerobic exercise, resistance training, cooperative games, exergaming, or football, among others, induce improvements on HRQoL in people with severe mental disorder (Méndez-Aguado et al. 2023) and people with posttraumatic stress disorder (Björkman and Ekblom 2022). In particular, web-based interventions including several PA types (resistance training, aerobic exercise, concurrent training, or yoga) showed improvements on HRQoL in patients with depressive and anxiety disorders, according to Carneiro et al. (2022).

All these studies support the growing evidence examining the influence of PA interventions in different domains of HRQoL in clinical populations and confirm the need for implementing PA recommendations in clinical practice (Jones et al. 2021).

Key Facts of Breast Cancer

- Globally, incidence of breast cancer has increased more than 20% since 2008.
- In 2020, about 7.8 million women had been diagnosed with breast cancer within the previous 5 years worldwide.
- A total of 685,000 people was dead in 2020 because of breast cancer.
- In high-income countries, breast cancer five-year survival rate exceed 90%, whereas it is remarkably lower in India (60%) or in South Africa (40%).
- Approximately, 99–99.5% of breast cancer cases occur in women.

Mini-dictionary of Terms

- **Physical activity.** Any bodily movement produced by skeletal muscles that requires energy expenditure. Physical activity refers to all movement including during leisure time, for transport to get to and from places, or as part of a person's work.
- **Quality of life.** Concept which aims to capture the well-being, regarding both positive and negative elements at a specific point in time. Common facets of quality of life include personal health, relationships, education status, work environment, social status, wealth, a sense of security and safety, freedom, autonomy in decision-making, social-belonging, and their physical surroundings.
- **Breast cancer.** An out-of-control growth of cells in the breast (one or both breasts).
- **Aerobic exercise.** The type of repetitive, structured physical activity that requires the body's metabolic system to use oxygen to produce energy.
- **HIIT.** High-intensity interval training consists of repeated bouts of high-intensity effort followed by varied recovery times.
- **Resistance exercise.** The training aimed to increase power and strength using static, dynamic actions or both, including all forms of training that involves working against loads that greater than normally experienced.
- **Concurrent training.** The combination of resistance and endurance training in a periodized program.

Summary Points

- Physical activity has shown to induce significant benefits on health-related quality of life in clinical populations.
- In people with cancer, physical activity is feasible and safe and improves all domains of health-related quality of life.
- The international physical activity guidelines indicate that people with breast cancer should, ideally, undergo 2–3 days per week for 20–40 min of moderate-intensity aerobic exercise and 2–3 days per week of two sets (8–12 repetitions) of moderate to vigorous resistance training.

- In people living with breast cancer, aerobic exercise, high-intensity interval training, resistance training, and aerobic exercise combined with resistance training (i.e., concurrent training) interventions can significantly enhance health-related quality of life.
- Concurrent training (including both aerobic and resistance training) induces the highest benefits on HRQoL in breast cancer survivors, and including mind-body (ideally) or aquatic exercises should be considered.
- Mind-body interventions and aquatic exercise also improve HRQoL, but other types of exercise interventions might have further benefits.
- Any type of exercise intervention combined with a dietary intervention have also shown to have a beneficial effect on all HRQoL domains in breast cancer survivors.
- Benefits of exercise interventions on HRQoL in breast cancer survivors are not sustained once exercise is discontinued, which indicates that exercise should become a habit in people with breast cancer.
- There is little evidence on the effects of exercise interventions in individuals with metastatic breast cancer, and further research is needed.

References

Aaronson NK, Ahmedzai S, Bergman B, et al (1993) The European organization for research and treatment of cancer QLQ-C30: a quality-of-life instrument for use in international clinical trials in oncology. J Natl Cancer Inst 85:365–376. https://doi.org/https://doi.org/10.1093/jnci/85.5.365

Abrams DB, Turner JR, Baumann LC et al (2013) Aerobic Exercise. In: Encyclopedia of behavioral medicine. Springer, New York, pp 48–49

American Cancer Society (2021) Common treatment approaches

American College of Sports Medicine (2014) High-intensity interval training

Andersen HH, Vinther A, Lund CM et al (2022) Effectiveness of different types, delivery modes and extensiveness of exercise in patients with breast cancer receiving systemic treatment – a systematic review and meta-analysis. Crit Rev Oncol Hematol 178:103802

Anderson L, Oldridge N, Thompson DR et al (2016) Exercise-based cardiac rehabilitation for coronary heart disease cochrane systematic review and meta-analysis. J Am Coll Cardiol:67, 1–12. https://doi.org/10.1016/j.jacc.2015.10.044

Aune D, Markozannes G, Abar L et al (2022) Physical activity and health-related quality of life in women with breast cancer: a meta-analysis. JNCI Cancer Spectr 6. https://doi.org/10.1093/jncics/pkac072

Björkman F, Ekblom Ö (2022) Physical exercise as treatment for PTSD: a systematic review and meta-analysis. Mil Med 187:E1103–E1113

Blaess J, Goepfert T, Geneton S et al (2023) Benefits & risks of physical activity in patients with systemic lupus erythematosus: a systematic review of the literature. Semin Arthritis Rheum 58:152128

Bò MC, Merlo A, Ligabue MB et al (2023) Self-managed physical activity in breast cancer survivors: a scoping review. PLoS One 18:e0284807. https://doi.org/10.1371/journal.pone.0284807

Bolam KA, Mijwel S, Rundqvist H, Wengström Y (2019) Two-year follow-up of the OptiTrain randomised controlled exercise trial. Breast Cancer Res Treat 175:637–648. https://doi.org/10.1007/s10549-019-05204-0

Borg G (1998) Borg's perceived exertion and pain scales. Human Kinetics, Champaign
Brady MJ, Cella DF, Mo F et al (1997) Reliability and validity of the functional assessment of cancer therapy-breast quality-of-life instrument. J Clin Oncol 15:974–986
Brownson-Smith R, Orange ST, Cresti N et al (2023) Effect of exercise before and/or during taxane-containing chemotherapy treatment on chemotherapy-induced peripheral neuropathy symptoms in women with breast cancer: systematic review and meta-analysis. J Cancer Surviv
Bucciarelli V, Bianco F, Di Blasio A, et al (2023) Cardiometabolic profile, physical activity, and quality of life in breast cancer survivors after different physical exercise protocols: a 34-month follow-up study. J Clin Med 12. https://doi.org/10.3390/jcm12144795
Calonego C, Alberton CL, Santagnello SB et al (2023) Impact of resistance training volume on physical and perceptual outcomes of breast cancer survivors submitted to a combined training program: a randomized, single-blinded study. J Phys Act Health 20:204–216. https://doi.org/10.1123/jpah.2022-0097
Campbell KL, Winters-Stone KM, Wiskemann J et al (2019) Exercise guidelines for cancer survivors: consensus statement from international multidisciplinary roundtable. Med Sci Sports Exerc 51:2375–2390. https://doi.org/10.1249/MSS.0000000000002116
Cardoso F, Rihani J, Harmer V et al (2023) Quality of life and treatment-related side effects in patients with HR+/HER2− advanced breast cancer: findings from a multicountry survey. Oncologist 28:856–865. https://doi.org/10.1093/oncolo/oyad207
Carneiro L, Rosenbaum S, Ward PB et al (2022) Web-based exercise interventions for patients with depressive and anxiety disorders: a systematic review of randomized controlled trials. Braz J Psychiatr 44:331–341. https://doi.org/10.1590/1516-4446
Caspersen CJ, Powell KE, Christenson GM (1985) Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public Health Rep 100:126–131
Cella DF, Tulsky DS, Gray G et al (1993) The functional assessment of cancer therapy scale: development and validation of the general measure. J Clin Oncol 11:570–579
Chen L, Peng P, Xu Z, Ding X (2023a) The effects of exercise on the quality of life of patients with breast cancer: a systematic review and meta-analysis based on the QLQ-C30 quality of life scale. Gland Surg 12:633–650. https://doi.org/10.21037/gs-23-126
Chen X, Shi X, Yu Z, Ma X (2023b) High-intensity interval training in breast cancer patients: a systematic review and meta-analysis. Cancer Med 12:17692–17705
Da Hora TC, Lima K, Maciel RRBT (2019) The effect of therapies on the quality of life of patients with systemic lupus erythematosus: a meta-analysis of randomized trials. Adv Rheumatol 59:34. https://doi.org/10.1186/s42358-019-0074-8
Delrieu L, Pialoux V, Pérol O et al (2020) Feasibility and health benefits of an individualized physical activity intervention in women with metastatic breast cancer: intervention study. JMIR Mhealth Uhealth 8:e12306. https://doi.org/10.2196/12306
Erickson KI, Hillman C, Stillman CM et al (2019) Physical activity, cognition, and brain outcomes: a review of the 2018 physical activity guidelines. Med Sci Sports Exerc 51:1242–1251. https://doi.org/10.1249/MSS.0000000000001936
European Society for Medical Oncology (2018) ESMO patient guide series based on the ESMO clinical practice guidelines
EuroQoL Group (1990) EuroQol*-a new facility for the measurement of health-related quality of life. Health Policy (New York) 16:199–206
Faíl LB, Marinho DA, Marques EA et al (2022) Benefits of aquatic exercise in adults with and without chronic disease – a systematic review with meta-analysis. Scand J Med Sci Sports 32:465–486
Farajivafa V, Khosravi N, Rezaee N et al (2023) Effectiveness of home-based exercise in breast cancer survivors: a randomized clinical trial. BMC Sports Sci Med Rehabil 15:96. https://doi.org/10.1186/s13102-023-00710-7
Feng YY, Chaves GSS, Shi W et al (2021) Education interventions in Chinese cardiac patients on health behaviours, disease-related knowledge, and health outcomes: a systematic review and meta-analysis. Patient Educ Couns 104:1018–1029. https://doi.org/10.1016/j.pec.2020.12.001

Fiatarone Singh M, Hackett D, Schoenfeld B et al (2019) Resistance training for health. American College of Sports Medicine

Ficarra S, Thomas E, Bianco A et al (2022) Impact of exercise interventions on physical fitness in breast cancer patients and survivors: a systematic review. Breast Cancer 29:402–418. https://doi.org/10.1007/s12282-022-01347-z

Fresno-Alba S, Leyton-Román M, Mesquita da Silva S, Jiménez-Castuera R (2023) Predicting quality of life in women with breast cancer who engage in physical exercise: the role of psychological variables. Healthcare (Switzerland) 11. https://doi.org/10.3390/healthcare11142088

García-Soidán JL, Pérez-Ribao I, Leirós-Rodríguez R, Soto-Rodríguez A (2020) Long-term influence of the practice of physical activity on the self-perceived quality of life of women with breast cancer: a randomized controlled trial. Int J Environ Res Public Health 17:1–12. https://doi.org/10.3390/ijerph17144986

Gerland L, Baumann FT, Niels T (2021) Resistance exercise for breast cancer patients? Evidence from the last decade. Breast Care 16:657–663. https://doi.org/10.1159/000513129

Global Cancer Observatory (2020a) Cancer today. https://gco.iarc.fr/today/online-analysis-pie?v=2020&mode=cancer&mode_population=continents&population=900&populations=900&key=total&sex=0&cancer=39&type=0&statistic=5&prevalence=0&population_group=0&ages_group%5B%5D=0&ages_group%5B%5D=17&nb_items=7&group_cancer=1&include_nmsc=1&include_nmsc_other=1&half_pie=0&donut=0. Accessed 12 Dec 2023

Global Cancer Observatory (2020b) Cancer tomorrow. https://gco.iarc.fr/tomorrow/en/dataviz/trends?mode=cancer&group_populations=0&multiple_populations=0&multiple_cancers=1&types=0&cancers=20. Accessed 12 Dec 2023

Gong X, Rong G, Wang Z et al (2022) Baduanjin exercise for patients with breast cancer: a systematic review and meta-analysis. Compl Ther Med 71. https://doi.org/10.1016/j.ctim.2022.102886

Hagstrom AD, Marshall PWM, Lonsdale C et al (2016) Resistance training improves fatigue and quality of life in previously sedentary breast cancer survivors: a randomised controlled trial. Eur J Cancer Care (Engl) 25:784–794. https://doi.org/10.1111/ecc.12422

Hong XL, Cheng LJ, Feng RC et al (2024) Effect of physio-cognitive dual-task training on cognition in pre-ageing and older adults with neurocognitive disorders: a meta-analysis and meta-regression of randomized controlled trial. Arch Gerontol Geriatr 116:105161. https://doi.org/10.1016/j.archger.2023.105161

Hsueh EJ, Loh EW, Lin JJA, Tam KW (2021) Effects of yoga on improving quality of life in patients with breast cancer: a meta-analysis of randomized controlled trials. Breast Cancer 28:264–276. https://doi.org/10.1007/s12282-020-01209-6

Isanejad A, Nazari S, Gharib B, Motlagh AG (2023) Comparison of the effects of high-intensity interval and moderate-intensity continuous training on inflammatory markers, cardiorespiratory fitness, and quality of life in breast cancer patients. J Sport Health Sci 12:674–689. https://doi.org/10.1016/j.jshs.2023.07.001

Joaquim A, Leão I, Antunes P et al (2022) Impact of physical exercise programs in breast cancer survivors on health-related quality of life, physical fitness, and body composition: evidence from systematic reviews and meta-analyses. Front Oncol 12. https://doi.org/10.3389/fonc.2022.955505

Jones M, Bright P, Hansen L et al (2021) Promoting physical activity in a primary care practice: overcoming the barriers. Am J Lifestyle Med 15:158–164. https://doi.org/10.1177/1559827619867693

Kanaley JA, Colberg SR, Corcoran MH et al (2022) Exercise/physical activity in individuals with type 2 diabetes: a consensus statement from the American College of Sports Medicine. Med Sci Sports Exerc 54:353–368. https://doi.org/10.1249/MSS.0000000000002800

Kendall SJ, Heinze S, Blanchard C et al (2023) Exercise programming modelling a standard of care approach improves physical health and patient-reported outcomes in individuals living with

breast cancer: a pilot study. Curr Oncol 30:7203–7217. https://doi.org/10.3390/curroncol30080522

Kent M (2006) The Oxford dictionary of sports science & medicine. Oxford University Press

Kraus VB, Sprow K, Powell KE et al (2019) Effects of physical activity in knee and hip osteoarthritis: a systematic umbrella review. Med Sci Sports Exerc 51:1324–1339. https://doi.org/10.1249/MSS.0000000000001944

Lake B, Damery S, Jolly K (2022) Effectiveness of weight loss interventions in breast cancer survivors: a systematic review of reviews. BMJ Open 12:e062288. https://doi.org/10.1136/bmjopen-2022-062288

Lee K, Norris MK, Wang E, Dieli-Conwright CM (2021) Effect of high-intensity interval training on patient-reported outcomes and physical function in women with breast cancer receiving anthracycline-based chemotherapy. Support Care Cancer 29:6863–6870. https://doi.org/10.1007/s00520-021-06294-7

Li W, You F, Wang Q, et al (2023) Effects of Tai Chi Chuan training on the QoL and psychological well-being in female patients with breast cancer: a systematic review of randomized controlled trials. Front Oncol 13. https://doi.org/10.3389/fonc.2023.1143674

Lin Y, Wu C, He C et al (2023) Effectiveness of three exercise programs and intensive follow-up in improving quality of life, pain, and lymphedema among breast cancer survivors: a randomized, controlled 6-month trial. Support Care Cancer 31:9. https://doi.org/10.1007/s00520-022-07494-5

Maccarone MC, Venturini E, Menegatti E et al (2023) Water-based exercise for upper and lower limb lymphedema treatment. J Vasc Surg Venous Lymphat Disord 11:201–209. https://doi.org/10.1016/j.jvsv.2022.08.002

Mavropalias G, Cormie P, Peddle-McIntyre CJ et al (2023) The effects of home-based exercise therapy for breast cancer-related fatigue induced by radical radiotherapy. Breast Cancer 30:139–150. https://doi.org/10.1007/s12282-022-01408-3

Méndez-Aguado C, Cangas AJ, Aguilar-Parra JM, Lirola MJ (2023) Benefits, facilitators and barrier reductions in physical activity programmes for people with severe mental disorder: a systematic review. Healthcare (Switzerland) 11. https://doi.org/10.3390/healthcare11091215

Mijwel S, Backman M, Bolam KA et al (2018) Adding high-intensity interval training to conventional training modalities: optimizing health-related outcomes during chemotherapy for breast cancer: the OptiTrain randomized controlled trial. Breast Cancer Res Treat 168:79–93. https://doi.org/10.1007/s10549-017-4571-3

Mijwel S, Jervaeus A, Bolam KA et al (2019) High-intensity exercise during chemotherapy induces beneficial effects 12 months into breast cancer survivorship. J Cancer Surviv 13:244–256. https://doi.org/10.1007/s11764-019-00747-z

Moraes RF, Ferreira-Júnior JB, Marques VA et al (2021) Resistance training, fatigue, quality of life, anxiety in breast cancer survivors. J Strength Cond Res 35:1350–1356

Mur-Gimeno E, Postigo-Martin P, Cantarero-Villanueva I, Sebio-Garcia R (2022) Systematic review of the effect of aquatic therapeutic exercise in breast cancer survivors. Eur J Cancer Care (Engl) 31:e13535. https://doi.org/10.1111/ecc.13535

National Center for Complementary and Integrative Health (2021) Complementary, alternative, or integrative health: what's in a name? https://www.nccih.nih.gov/health/complementary-alternative-or-integrative-health-whats-in-a-name. Accessed 29 Nov 2023

Pérez-Bilbao T, Alonso-Dueñas M, Peinado AB, San Juan AF (2023) Effects of combined interventions of exercise and diet or exercise and supplementation on breast cancer patients: a systematic review. Nutrients 15. https://doi.org/10.3390/nu15041013

Pescatello LS, Buchner DM, Jakicic JM et al (2019) Physical activity to prevent and treat hypertension: a systematic review. Med Sci Sports Exerc 51:1314–1323. https://doi.org/10.1249/MSS.0000000000001943

Rice BI (2001) Mind-body interventions. Diabetes Spectr 14:213

Schmitt J, Lindner N, Reuss-Borst M et al (2016) A 3-week multimodal intervention involving high-intensity interval training in female cancer survivors: a randomized controlled trial. Physiol Rep 4. https://doi.org/10.14814/phy2.12693

Schulz SVW, Laszlo R, Otto S et al (2018) Feasibility and effects of a combined adjuvant high-intensity interval/strength training in breast cancer patients: a single-center pilot study. Disabil Rehabil 40:1501–1508. https://doi.org/10.1080/09638288.2017.1300688

Sheean P, Matthews L, Visotcky A et al (2021) Every day counts: a randomized pilot lifestyle intervention for women with metastatic breast cancer. Breast Cancer Res Treat 187:729–741. https://doi.org/10.1007/s10549-021-06163-1

Shiraev T, Barclay G (2012) Evidence based exercise clinical benefits of high intensity interval training. Aust Fam Physician 41:960–962

Singh B, Spence RR, Steele ML et al (2018) A systematic review and meta-analysis of the safety, feasibility, and effect of exercise in women with stage II+ breast cancer. Arch Phys Med Rehabil 99:2621–2636. https://doi.org/10.1016/j.apmr.2018.03.026

Soriano-Maldonado A, Díez-Fernández DM, Esteban-Simón A et al (2023) Effects of a 12-week supervised resistance training program, combined with home-based physical activity, on physical fitness and quality of life in female breast cancer survivors: the EFICAN randomized controlled trial. J Cancer Surviv 17:1371–1385. https://doi.org/10.1007/s11764-022-01192-1

Sprangers MAG, Groenvold M, Arraras JI et al (1996) The European Organization for Research and Treatment of Cancer breast cancer-specific quality-of-life questionnaire module: first results from a three-country field study. J Clin Oncol 14:2756–2768

Sturgeon KM, Smith AM, Federici EH et al (2022) Feasibility of a tailored home-based exercise intervention during neoadjuvant chemotherapy in breast cancer patients. BMC Sports Sci Med Rehabil 14. https://doi.org/10.1186/s13102-022-00420-6, 31

Su JJ, Yu DSF, Paguio JT (2020) Effect of eHealth cardiac rehabilitation on health outcomes of coronary heart disease patients: a systematic review and meta-analysis. J Adv Nurs 76:754–772. https://doi.org/10.1111/jan.14272

Swinnen N, Vandenbulcke M, Vancampfort D (2020) Exergames in people with major neurocognitive disorder: a systematic review. Disabil Rehabil Assist Technol 1–14:376. https://doi.org/10.1080/17483107.2020.1785566

Teoli D, Bhardwaj A (2023) Quality of life. National Library of Medicine, Treasure Island

U.S. Department of Health and Human Services (2018) Physical activity guidelines for Americans, 2nd edn. U.S. Department of Health and Human Services, Washington, DC

U.S. Department of Health and Human Services FDA Center for Drug Evaluation and Research, U.S. Department of Health and Human Services FDA Center for Biologics Evaluation and Research, U.S. Department of Health and Human Services FDA Center for Devices and Radiological Health (2006) Guidance for industry: patient-reported outcome measures: use in medical product development to support labelling claims: draft guidance. Health Qual Life Outcomes 4:79. https://doi.org/10.1186/1477-7525-4-79

Veiga-Seijo R, Perez-Lopez ME, Fernandez-Lopez U et al (2023) Wellbeing and complementary therapies in breast cancer peripheral neuropathy care: a scoping review focused on foot health. Cancers (Basel) 15. https://doi.org/10.3390/cancers15072110

Wang J, Chen X, Wang L et al (2022) Does aquatic physical therapy affect the rehabilitation of breast cancer in women? A systematic review and meta-analysis of randomized controlled trials. PLoS One 17:e0272337. https://doi.org/10.1371/journal.pone.0272337

Wang TC, Chen PL, Liao WC, Tsai IC (2023) Differential impact of exercises on quality-of-life improvement in breast cancer survivors: a network meta-analysis of randomized controlled trials. Cancers (Basel) 15. https://doi.org/10.3390/cancers15133380

Ware JE, Sherbourne CD (1992) The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care 30:473–483

Ware J, Kosinski M, Keller S (1996) A 12-item short-form health survey. Med Care 34:220–233. https://doi.org/10.1097/00005650-199603000-00003

World Health Organization (2020) WHO guidelines on physical activity and sedentary behaviour. WHO

World Health Organization (2022) Physical activity. WHO

World Health Organization WHOQOL: measuring quality of life. https://www.who.int/toolkits/whoqol. Accessed 8 Jan 2024

Yang Y, Wang G, Zhang S et al (2022) Efficacy and evaluation of therapeutic exercises on adults with Parkinson's disease: a systematic review and network meta-analysis. BMC Geriatr 22:813. https://doi.org/10.1186/s12877-022-03510-9

Yee J, Davis GM, Hackett D et al (2019) Physical activity for symptom management in women with metastatic breast cancer: a randomized feasibility trial on physical activity and breast metastases. J Pain Symptom Manag 58:929–939. https://doi.org/10.1016/j.jpainsymman.2019.07.022

Zhu J, Niu H, Lu D et al (2023) Research on the applicability of an exercise rehabilitation app aiming to improve the mental and physical health of breast cancer patients in the post-operative period. Front Psychol 14. https://doi.org/10.3389/fpsyg.2023.1126284