Asia-Pacific Journal of Oncology Nursing 9 (2022) 100117

Contents lists available at ScienceDirect

Asia-Pacific Journal of Oncology Nursing

journal homepage: www.apjon.org

Review

Effect of a telehealth-based exercise intervention on the physical activity of patients with breast cancer: A systematic review and meta-analysis

Yueyang Peng [a], Kun Zhang [a], Luyao Wang [a], Yunyun Peng [a], Zixuan Liu [b], Li Liu [a], Yang Luo [a], Can Gu [a,*]

[a] *Xiangya School of Nursing, Central South University, Changsha, China*
[b] *School of Nursing, Xinjiang Medical University, Xinjiang, China*

A R T I C L E I N F O

Keywords:
Breast cancer
Telehealth
Exercise
Physical activity

A B S T R A C T

Telehealth-based exercise intervention as a non-pharmacological intervention has gradually emerged in breast cancer (BC), which shows feasibility and high levels of patient satisfaction. This systematic review aims to identify the effect of telehealth-based exercise interventions on the physical activity (PA) of patients with BC. We searched CENTRAL, CINAHL, PsycINFO, EMBASE, PubMed, Web of Science, ClinicalTrials.gov, CNKI, Wanfang, VIP, and SinoMed. Study selection and quality appraisal were performed independently by two reviewers. The review protocol was registered in PROSPERO (CRD42022326484). Nine studies, which included 1127 patients with BC, were identified. Compared with usual care, the telehealth-based exercise intervention had a significantly positive effect on PA (Standardized mean difference (SMD) = 0.26, 95% confidence interval (CI) 0.09 to 0.43, $P = 0.003$), aerobic capacity (SMD = 0.20, 95% CI 0.03 to 0.38, $P = 0.02$), upper body function (Mean difference (MD) = −4.56, 95% CI −7.66 to −1.47, $P = 0.004$), upper muscle strength (SMD = 0.26, 95% CI 0.09 to 0.42, $P = 0.002$), lower muscle strength (SMD = −0.95, 95% CI −1.27 to −0.62, $P < 0.00001$), abdominal muscle strength (MD = 23.85, 95% CI 13.84 to 33.86, $P < 0.000,01$), fatigue (SMD = 0.56, 95% CI 0.13 to 1.00, $P = 0.01$), and quality of life (SMD = 0.26, 95% CI 0.04 to 0.49, $P = 0.02$). Conversely, anthropometric and body composition and pain did not differ significantly between the two groups. Telehealth-based exercise intervention improved PA, physical performance, fatigue, and quality of life of patients with BC compared with routine care, which should be promoted clinically as a comprehensive treatment for BC.

Introduction

Breast cancer (BC) is common in women; approximately 2.26 million new BC cases were diagnosed in 2020 worldwide.[1] Effective cancer screening, early diagnosis, and advanced treatment have increased the survival rate of women with BC.[2,3] However, the diagnosis and treatment of BC impose physical and psychological burdens on patients. After completing primary cancer treatment, patients with BC can continuously experience late and long-term treatment-related side effects such as pain, fatigue, obesity, limited movement in the upper limbs, muscle strength loss, lymphedema, and menopausal symptom.[4–7] Based on the available literature, 7%–52% of patients with BC have severe fatigue symptoms, and the strength in lower and upper extremities was reduced by 25% and 12%–16% compared with healthy women.[8,9] In addition, 68% and 74% of patients with BC gained weight and body fat within 1–3 years after diagnosis.[10]

Non-pharmacological interventions such as cognitive-behavioral interventions, acupuncture needling, art therapy, and exercise play an increasingly important role in BC therapy.[11,12] Notably, exercise is an effective non-pharmacological interventions to increase physical activity (PA) and reduce treatment-related side effects in patients with BC.[13] After diagnosis, PA is strongly associated with low recurrence rate and improved survival for patients with BC.[14–16] Current exercise programs for BC intervention studies are primarily based on the amount of exercise recommended by the Physical Activity Guidelines of the U. S.[17] The 2018 Consensus statement from International Multidisciplinary Roundtable indicated that cancer survivors should perform 150 min of moderate–intensity (at least three times per week, each lasting at least 30 min) or 75 min of vigorous–intensity aerobic exercise two times a week, along with resistance and flexibility exercises.[18] Based on a recent systematic review, resistance exercise had positive effects on lymphedema,[19] and another meta-analysis of patients with BC, who are

* Corresponding author.
E-mail address: gucan_cs@csu.edu.cn (C. Gu).

https://doi.org/10.1016/j.apjon.2022.100117
Received 31 May 2022; Accepted 5 July 2022

receiving hormone therapy, revealed that aerobic plus resistance exercise had positive effects on cardiorespiratory function and pain.[20] Moreover, the positive intervention effect of stretching, yoga, qigong, and Pilates on the quality of life (QoL), body composition, pain, lymphedema, and psychological status was confirmed in a systematic review.[21] However, traditional face-to-face exercise interventions, such as regular group exercise rehabilitation in hospitals or gyms and private coaching, may increase patients' financial burden and reduce long-term adherence because of traffic congestion or personal time conflicts.[22] Furthermore, traditional healthcare services may be more challenging to implement in rural and remote areas because access to medical services might vary by geographical region.[23]

Telehealth is the remote delivery of healthcare through various telecommunication tools, including telephones, smartphones, and mobile wireless devices (with or without video connectivity),[24] which can address geographical barriers to clinical service delivery to patients.[25] Compared with the traditional medical service, telehealth has higher medical accessibility because of its cross-territory connectivity and cross-temporal interaction, and it shows excellent application potential in optimizing medical resource allocation.[26] The COVID-19 pandemic has boosted telemedicine in medical care visits, and the widespread use of telehealth has become an inevitable trend in the post-epidemic era.[27,28] Telehealth-based exercise interventions are easy to implement, flexible, and not limited by location, and they have gradually emerged. At present, various types of telehealth-based exercise could improve the treatment of physical and psychological symptoms and the QoL of patients with BC, which indicate their feasibility and high levels of patient satisfaction.[29,30] Therefore, exploring the specific effectiveness of telehealth-based exercise interventions in patients with BC is necessary.

Although similar previous systematic reviews have synthesized evidence on eHealth and mHealth interventions for patients with BC, this study has several differences compared with current works. With regard to intervention type, previous systematic reviews included multiple types of interventions, such as cognitive behavioral therapy, psychological education, diet, and exercise. By contrast, this systematic review included randomized controlled trials (RCTs) that only included exercise interventions to explore the role of exercise interventions in patients with BC. In addition, most existing systematic reviews address one form of eHealth interventions, such as mobile applications. This study did not restrict telehealth intervention forms to fully compare the effects of multiple telehealth-based exercise interventions. Furthermore, telehealth-based interventions may maximize patients' benefit to overcome geographical barriers, particularly in the context of the COVID-19 pandemic. However, the effectiveness of telehealth-based exercise interventions on the PA of patients with BC remains unclear. Therefore, this systematic review and meta-analysis of RCTs aimed to (1) evaluate the effectiveness of telehealth-based exercise interventions, (2) summarize different types of telehealth interventions, and (3) provide a scientific basis for the clinical application of personalized telehealth-based exercise interventions on BC.

Methods

Inclusion criteria

We established the following inclusion criteria using the acronym PICOS. P (population) includes women aged above 18 years diagnosed with BC. I (intervention) and C (comparison) include telehealth-based exercise intervention compared with waitlist control, standard education, and usual care. Telehealth-based exercise intervention should be delivered by smartphones, mobile apps, wearable monitors, video, email, web portals, and games, which can overcome the barriers of time and distance to provide aerobic and resistance exercises, yoga, Pilates intervention, and cognitive-behavioral therapy for patients.[24,31] Usual care refers to basic healthcare services, such as regular hospital visits for face-to-face healthcare and traditional health education about BC. O (outcomes) includes PA, anthropometric and body composition, aerobic capacity, body function, muscle strength, treatment-related side effects, and QoL. S (study design) only includes RCTs. The exclusion criteria were as follows: case reports, reviews, non-RCTs, duplicate reports, and studies without interesting data.

Outcomes

The primary outcome is PA, measured by standardized questionnaires (eg., Active Australia Survey, a 7-day PA recall) or other measures reported by studies (eg., sedentary behavior).

The secondary outcomes are as follows:

- Anthropometric and body composition were defined on the basis of each study and measured by diastolic blood pressure; systolic blood pressure; pressure and pulse rate; waist, arm, and hip circumferences; weight; body fat; lean mass; body mass index (BMI).
- Aerobic capacity was measured using standardized tests (eg., 6 min walk test or 3 min step test) or other measures reported by studies (eg., VO_2 max).
- Upper body function was measured using a standardized questionnaire (the disability of the arm, shoulder, and hand).
- Muscle strength, including upper, lower, and abdominal muscle strength, was measured by standardized tests (eg., lifting test and multiple sit-to-stand test) or other measures reported by studies (eg., digital dynamometers).
- Treatment-related side effects, including fatigue and pain, were measured by standardized questionnaires (eg., revised Piper Fatigue Scale and Neuropathic Pain Scale).
- QoL was measured using standardized questionnaires (eg., 36-item Short Form Health Survey and the Functional Assessment of Cancer Therapy-Breast).

Information sources and search strategy

Searches were performed in English and Chinese databases, such as PubMed, Embase, MEDLINE, CENTRAL, PsycINFO, CINAHL, and ClinicalTrials.gov for English literature and CNKI, Wanfang, VIP, and SinoMed for Chinese literature.

The search strategy aimed to locate published and unpublished studies. In this review, a three-step search strategy was utilized and was conducted in consultation with a health science librarian. First, an initial limited search of PubMed was performed, followed by the analysis of text words contained in the title and abstract, and index terms were used to describe the articles. Second, the search strategy, including all identified keywords and index terms, was adapted for each included information source and performed on January 23, 2022. Full-search strategies are provided in Supplementary Table 1. Finally, the reference list of all studies selected for critical appraisal was screened for additional studies.

Study selection

All identified citations were collated and uploaded into the Endnote X9 library, and duplicates were removed after the search. Titles and abstracts were screened by two independent reviewers (PY and LZ) based on the inclusion criteria for review. The full-text of selected citations was assessed in detail based on the inclusion criteria by two independent reviewers (PY and ZK) in the Endnote X9 library. Full-text studies that did not meet the inclusion criteria were excluded. Any disagreements between the reviewers were resolved through discussion or with a third reviewer (ZK).

Assessment of methodological quality

The researchers used the Cochrane Collaboration's tool to assess the risk of bias in the selected studies.[32] The tool assesses the selection bias, performance bias, detection bias, attrition bias, and reporting bias, including random sequence generation and allocation concealment, blinding of participants or personnel, blinding of outcome assessment, incomplete outcome data, and selective reporting. "Low risk of bias," "High risk of bias," or "Unknown risk of bias" were assigned to represent the risk of bias of included studies.

Data extraction

Researchers' designed forms were used to extract relevant data from the included studies. The data included the first author and year of publication, country, study design, purpose, subject, sample size, the intervention of experimental and control groups, duration, outcomes and instruments. Double data entry was used to record results and minimize the risk of errors. In case of missing data in the studies, attempts to contact the authors were made. Cross-tabulation was used to summarize and simplify the retrieved data.

Data synthesis

Studies were pooled in a statistical meta-analysis using RevMan V5.3 (Copenhagen: The Nordic Cochrane Center, Cochrane) to assess PA and other secondary outcomes based on available extracted data. Effect sizes, expressed as odds ratios and their 95% confidence intervals (CIs), were calculated for analysis. Heterogeneity was assessed statistically using standard chi-squared and I^2 tests. For other outcomes where statistical pooling was not possible, the findings were presented in narrative form, including tables, to aid in data presentation.

Results

Description of studies

A total of 7638 relevant studies matched the inclusion criteria during the database search. Of these studies, 1713 were excluded for either duplication. After a review of the title and abstract, 5895 studies were excluded. Only 30 studies were included for full-text reading, one of which was a pilot study. Three studies were found to involve participants irrelevant to this study. Nine studies were eliminated for ineligible intervention. Another two studies were eliminated because they failed to meet the selection criterion of being an RCT. In addition, three abstracts were excluded as they could not provide a complete picture of their studies, and two studies were repetitive. In total, nine studies that met the selection criteria were included in this review. Fig. 1 shows the flow diagram of the selection process of this study.

Study characteristics

The included studies were conducted in Australia,[33–35] China,[36,37] Spain,[38,39] the USA,[40] and Korea,[41] published between 2012 and 2021. Sample sizes varied from 60 to 356, with four studies having a sample under 80 participants, two studies between 80 and 100 participants, and three studies over 100. The mean participant age was 52 years (range = 47–62 years). All the included studies featured patients with BC in the total sample or at least one of the experimental groups and at least one control group and intervention.

Regarding telehealth technology, the reviewed studies confirmed that such a category could include a variety of technologies and systems. Among the included studies, three used an online system or soft media,[36,38,39] two telephone,[33,34] one email,[40] two portable technologies (e.g., for wearable technology activity monitor and pedometer),[35,41] and one motion capture technology.[37]

The key characteristics of these studies are presented in Table 1.

Methodological quality

The Cochrane Collaboration's tool was used to assess the risk of bias in RCTs. The overall risk of bias in RCTs was evaluated as "B" except for the study by Eakin et al.[33] , which was rated as "A" (Table 2 for full methodological quality assessment). All studies were determined as low bias risk in the random sequence generation. Seven studies[34,36,37,40–42] were rated

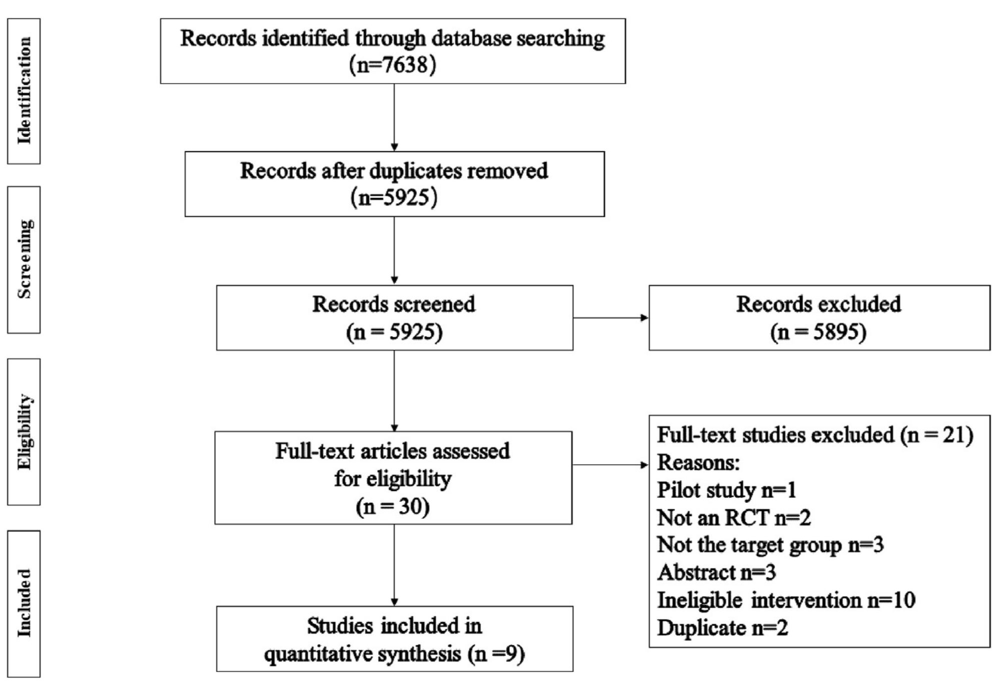

Fig. 1. Search results and study selection and inclusion process.

Table 1
Key data from the included studies.

Author/ Year	Study design	Purpose	Participants	Telehealth-based exercise intervention	Intervention Duration	Control groups	Outcomes instruments
Ariza-Garcia, 2019	A two-arm, assessor-blinded, parallel, efficacy RCT	To evaluate the effectiveness of a Web-based exercise program (e-CuidateChemo) and mitigate the side effects of chemotherapy on the physical being, anthropometric aspects, and body composition	68 patients with BC undergoing chemotherapy (Spain)	The e-CuidateChemo Intervention (a telerehabilitation program that uses an online system): Three sessions per week (on non-consecutive days). Each session was organized into a warm-up, a main, and a cool down part. (1) Resistance exercises: self-supporting and elastic bands. (2) A communication system between patients and research staff through an internal service.	8 weeks	Usual care	1. Anthropometric and body composition: a plastic tape measure, bioelectrical impedance 2. Aerobic capacity: 6 MWT 3. Muscle strength: the patient lying on their back and their knees bent, the multiple sit-to-stand test, dynamometers
Dong X, 2019	A randomized single-blinded controlled trial	To investigate the effects of the combined exercise intervention based on Internet and social media software (CEIBISMS) on postoperative patients with BC by evaluating the QoL, muscle strength, and cardiorespiratory capacity	60 patients with BC at phase I to III who have finished postoperative radiotherapy/ chemotherapy within 4 months to 2 years (China)	The combined exercise intervention based on Internet and social media software (CEIBISMS): (1) Muscle training: muscle strength, muscle endurance, and muscle function training. (2) Cardiorespiratory capacity training. (3) Postoperative BC rehabilitation knowledge.	12 weeks	Traditional treatment and rehabilitation based on daily specifications of the hospital	1. QoL: SF-36 2. Aerobic capacity: VO_2 max 3. Muscle strength: the stand-up and sit-down chair test and arm lifting test
Eakin, 2012	An RCT	To evaluate the feasibility and effectiveness of a telephone-delivered, mixed aerobic, and resistance exercise intervention for non-urban Australian women with BC	143 women with a first diagnosis of invasive BC aged 20–69 years (Australia)	Telephone-delivered exercise intervention: aerobic-based (moderate-to-vigorous intensity) exercise (such as brisk walking) each session and strength-based exercise at least two times a week.	8 months	Usual care	1. QoL: FACT-B+4 2. PA: the Active Australia Survey 3. Upper body function: DASH 4. Treatment-related side effects: FACIT
Galiano-Castillo, 2016	A two-arm, assessor-blinded, parallel, randomized controlled efficacy trial	To investigate the effectiveness of a telehealth system for improving adverse effects after an 8 week intervention and its maintenance after 6 months of follow-up in BC survivors	81 patients with BC at phases I to III (Spain)	The e-CUIDATE system online intervention: three sessions were delivered online, which contained a battery of specific exercises that were divided into three sections: (1) warm-up, (2) resistance and aerobic exercise training, and (3) cool down.	8 weeks	Usual care	1. QoL: EORTC QLQ-C30 2. Muscle strength: a distance of 0.30 m between heels and buttocks, the multiple sit-to-stand test, dynamometers 3. Treatment-related side effects: R-PFS, CBD
Hatchett, 2013	An RCT	To evaluate a social cognitive theory (SCT)-based email intervention designed to influence PA of sedentary patients recovering from BC	74 patients diagnosed with BC (America)	The social cognitive theory-based email Intervention: For the first 6 weeks of the intervention, participants were assigned to the intervention group to receive messages weekly; from weeks 7–12, participants received messages every other week and had access to an e-counselor.	12 weeks	Usual care	1. PA: a 7-day PAR
Hayes, 2013	An RCT	To compare the effectiveness of the face-to-face (FtF) and telephone-delivered exercise intervention on the QoL and patient-reported and clinically measured function and treatment-related side effects	194 patients diagnosed with invasive BC (Australia)	The pragmatic, translational exercise intervention via telephone: 16 scheduled sessions (in person or via telephone) with a designated exercise physiologist, starting weekly and tapering to monthly contacts after 4 months.	8 months	Usual care	1. QoL: FACT-B +4 2. Anthropometric and body composition: analog SecaTM scales 3. PA: the Active Australia Survey 4. Aerobic capacity: the 3 min step test 5. Upper body function: DASH 6. Treatment-related symptoms: FACIT, the Greene Climacteric Scale, the Neuropathic Pain Scale, BIS

(*continued on next page*)

Table 1 (*continued*)

Author/ Year	Study design	Purpose	Participants	Telehealth-based exercise intervention	Intervention Duration	Control groups	Outcomes instruments
Lynch, 2019	An RCT	To determine the efficacy of a wearable technology-based intervention for increasing moderate-to-vigorous physical activity (MVPA) and reducing sedentary behavior among postmenopausal BC survivors	83 postmenopausal patients with BC at phases I to III (Australia)	The ACTIVity And TEchnology (ACTIVATE) intervention: (1) Behavioral feedback and goal setting session. (2) Wearable technology activity monitor. (3) Telephone-delivered behavioral counseling.	12 weeks	Waitlist control	1. PA: Actigraph GT3X+, an activPAL
Uhm, 2017	A prospective, quasi-randomized multicenter trial	To investigate and compare the effects of mobile health (mHealth) and pedometer with a conventional exercise program using a brochure on physical function and QoL	356 patients diagnosed with BC aged 20–70 years (Korea)	The home-based program of aerobic and resistance exercises with a pedometer: (1) Resistance exercises: lateral raise, biceps curl, and scapular retraction. (2) A smartphone exercise application called Smart After Care and an InBodyBand pedometer.	12 weeks	The home-based program of aerobic and resistance exercises with a brochure	1. QoL: EORTC QLQ -C30, EORTC QLQ-BR23 2. Anthropometric and body composition: BMI, SBP, DBP, pulse rate, arm circumference 3. PA: IPAQ-SF 4. Aerobic capacity: 2 MWT
Ye, 2021	An RCT	To explore the effect of applying an online rehabilitation program based on markerless motion capture technology to home-residing post-surgical patients with BC	68 patients diagnosed with BC after operation (China)	The online rehabilitation exercise program based on markerless motion capture technology: (1) Pre-recording hundreds of videos of different people doing post-breast cancer rehabilitation exercises in different backgrounds wearing different clothes to construct a parametric human model for training. (2) Capture the changing appearance of patient's limbs in the corresponding frames from the video cut-frame images. (3) Compare the corresponding frames of captured patient movements using the standardized model.	3 months	Usual care	1. Upper body function: DASH 2. Muscle strength: a hand-muscle developer

6 MWT, 6 min walk test; BIS, bioimpedance spectroscopy; BMI, body mass index; CBD, the Spanish version of the Brief Pain Inventory; DASH, the Disability of Arm, Shoulder and Hand; DBP, diastolic blood pressure; EORTC QLQ-BR23, the Quality of Life Questionnaire Breast Cancer Module 23; EORTC QLQ-C30, the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30; FACIT, the Functional Assessment of Chronic Illness Therapy–Fatigue Scale; FACT-B+4, the Functional Assessment of Cancer Therapy-Breast; IPAQ-SF, the International Physical Activity Questionnaire-Short Form; PAR, physical activity recall; QoL, quality of life; R-PFS, the Piper Fatigue Scale-revised; RCT, randomized controlled trial; SBP, systolic blood pressure; SF-36, the 36-item Short Form Health Survey; VO_2max, maximal oxygen uptake.

Table 2
Critical appraisal results for randomized controlled trials.

Author, Year	Random sequence generation	Allocation concealment	Incomplete outcome data addressed adequately	Blinding of participants	Blinding of outcomes	Selective outcome reporting	Other bias	Final evaluation
Ariza-Garcia, 2019	L	L	U	U	H	L	L	B
Dong X, 2019	L	U	U	L	L	L	L	B
Eakin, 2012	L	L	L	L	L	L	L	A
Galiano-Castillo, 2016	L	L	U	L	L	L	L	B
Hatchett, 2013	L	U	U	U	L	L	L	B
Hayes, 2013	L	U	U	U	L	L	L	B
Lynch, 2019	L	L	U	U	L	L	L	B
Uhm, 2017	L	U	U	U	L	L	L	B
Ye, 2021	L	U	U	U	L	L	L	B

H, high risk of bias; L, low risk of bias; U, unclear risk of bias.

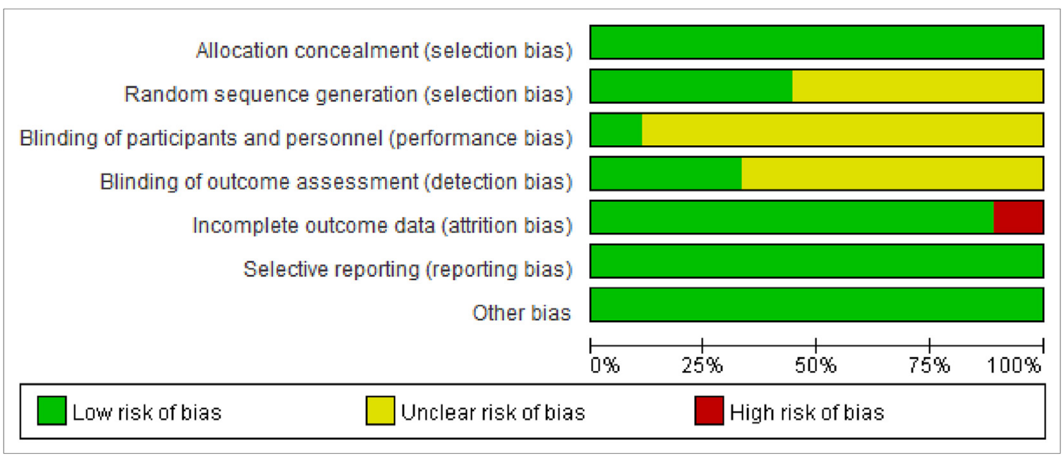

Fig. 2. Results of risk of bias analysis.

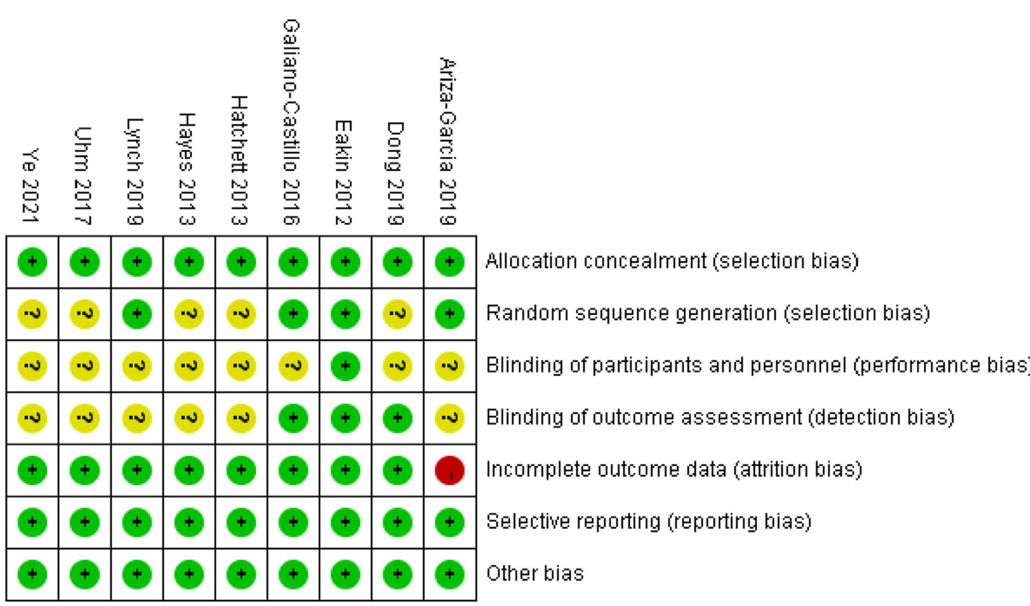

Fig. 3. Summary of the results of the risk of bias.

as showing unclear bias risk as the allocation concealment was not classified. Blinding information in most studies was insufficiently described to allow reviewers to determine whether subjects and interventions were actually blinded, except for one study.[33] This latter case was evaluated as having low bias risk. Three studies[33,36,39] had insufficient information for the blinding of the outcome assessment, which showed low bias risk. For attrition bias, one study[38] was rated as high bias risk because of the increased loss ratio of follow-up. All studies reported relevant outcome indicators, which were evaluated as low bias risk similar to other biases. Figs. 2 and 3 show the results of the risk of bias analysis.

Effects of interventions

Physical activity as the primary outcome

Four studies, encompassing 521 patients, reported the result of PA, which was measured on the basis of the moderate-to-vigorous physical activity, the International Physical Activity Questionnaire-Short Form (IPAQ-SF),[41] and a 7-day PA recall.[40] Given the between-study homogeneity ($P = 0.15$, $I^2 = 43\%$), we used a fixed-effect model to calculate the standardized mean difference (SMD) effect size. The result showed that telehealth could increase patients' PA, with statistical difference (SMD = 0.26, 95% CI 0.09 to 0.43, $P = 0.003$; Fig. 4).

Only one study compared sedentary behavior between telehealth-based exercise intervention and convention intervention.[35] A statistically significant decrease was observed in total sitting time ($P = 0.01$) and prolonged bouts ($\geq$ 20 min) of sitting ($P = 0.04$).

Other secondary outcomes

Anthropometric and body composition

Two studies incorporating 378 participants defined as body composition as the BMI, which was measured on the basis of bioelectrical impedance. Given the between-study homogeneity ($P = 0.92$, $I^2 = 0\%$), we used a fixed-effect model to calculate the mean difference (MD) effect size. The result revealed that BMI did not differ between intervention and control groups (MD = −0.11, 95% CI −0.78 to 0.56, $P = 0.75$, Fig. 5).

Only one study compared systolic blood pressure, diastolic blood pressure, pulse rate, and arm circumference between telehealth-based exercise intervention and convention intervention.[41] All changes did not show a statistically significant difference between the two groups.

In addition, only one study compared waist and hip circumferences between telehealth-based exercise intervention and convention intervention.[38] No significant difference was observed between the two groups.

Aerobic capacity

Three studies incorporating 512 participants were included in the meta-analysis of aerobic capacity. Aerobic capacity was measured by using the 2 min walk test,[41] 3 min step test,[34] and 6 min walk test.[38] We used a fixed-effect model to calculate the SMD effect size because of between-study homogeneity ($P = 0.18$, $I^2 = 42\%$). The result revealed that telehealth could increase patients' aerobic capacity, with a

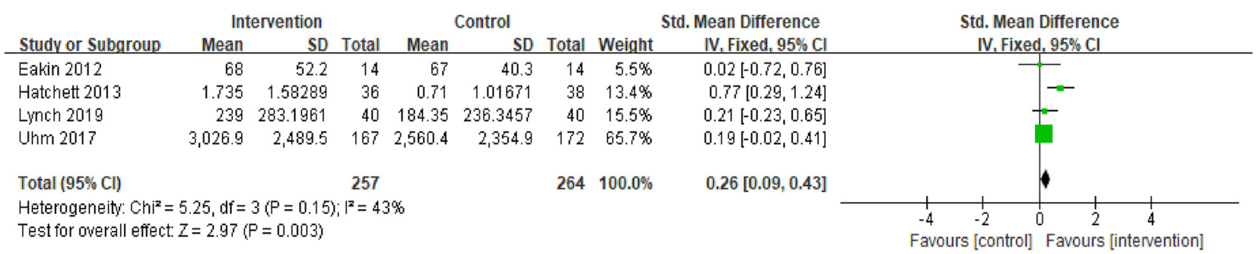

Fig. 4. Forest plot of the effect of telehealth-based exercise intervention on PA. PA, physical activity.

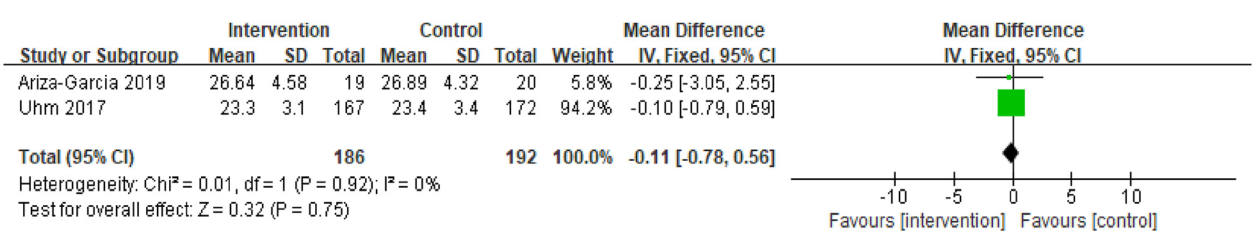

Fig. 5. Forest plot of the effect of telehealth-based exercise intervention on body composition.

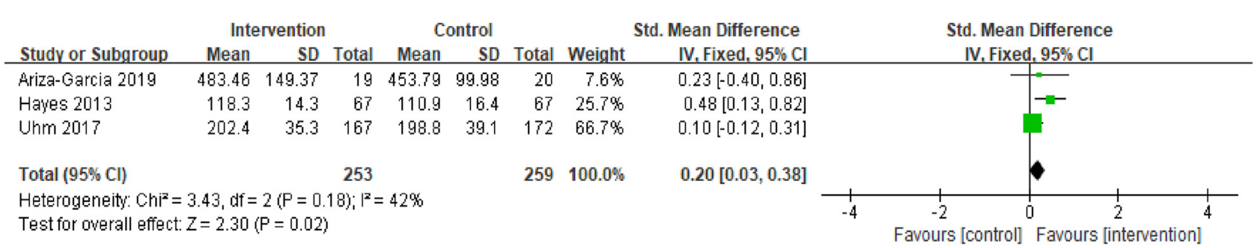

Fig. 6. Forest plot of the effect of telehealth-based exercise intervention on aerobic capacity.

statistical difference (SMD = 0.20, 95% CI 0.03 to 0.38, $P = 0.02$; Fig. 6).

Only one study compared VO_2max between telehealth-based exercise intervention and traditional intervention.[36] No significant difference was observed between the two groups ($P = 0.149$).

Upper body function

Three studies, encompassing 329 patients, reported upper body function, which was measured by using the Disability of Arm, Shoulder and Hand (DASH) questionnaire.[33,34,37] Given the between-study homogeneity ($P = 0.93$, $I^2 = 0\%$), we used a fixed-effect model to calculate the MD effect size. The result revealed that telehealth could improve patients' upper body function, with a statistical difference (MD = −4.56, 95% CI −7.66 to −1.47, $P = 0.004$; Fig. 7).

Muscle strength

Upper muscle strength

Five studies incorporating 572 participants defined upper muscle strength as hand grip strength. Upper muscle strength was measured by using the arm lifting test,[36] digital dynamometers,[38,39,41] and a hand-muscle developer.[37] We used a random-effect model to calculate the SMD effect size because of between-study homogeneity ($P = 0.52$, $I^2 = 0\%$). The result revealed that telehealth could improve patients' upper muscle strength, with a statistical difference (SMD = 0.26, 95% CI 0.09 to 0.42, $P = 0.002$; Fig. 8).

Lower muscle strength

Three studies incorporating 165 participants were included in the meta-analysis of lower body strength. Lower muscle strength was measured by using the multiple sit-to-stand test[38,39] and the stand-up and sit-down chair test.[36] Given the between-study homogeneity ($P = 0.76$, $I^2 = 0\%$), we used a fixed-effect model to calculate the SMD effect size. The result revealed that telehealth could improve patients' lower muscle strength, with a statistical difference (SMD = −0.95, 95% CI −1.27 to −0.62, $P < 0.000,01$; Fig. 9).

Abdominal muscle strength

Two studies encompassing 115 participants reported abdominal strength. Abdominal muscle strength was measured by patients lying on their back and their knees bent.[38,39] Given the between-study homogeneity ($P = 0.99$, $I^2 = 0\%$), we used a fixed-effect model to calculate the MD effect size. The result revealed that telehealth-based exercise intervention could improve patients' abdominal muscle strength, with a statistical difference (MD = 23.85, 95% CI 13.84 to 33.86, $P < 0.00001$; Fig. 10).

Treatment-related side effects

Fatigue

Three studies incorporating 346 participants reported fatigue. Fatigue was measured by using the Functional Assessment of Chronic Illness Therapy–Fatigue Scale (FACIT)[33,34] and the Piper Fatigue

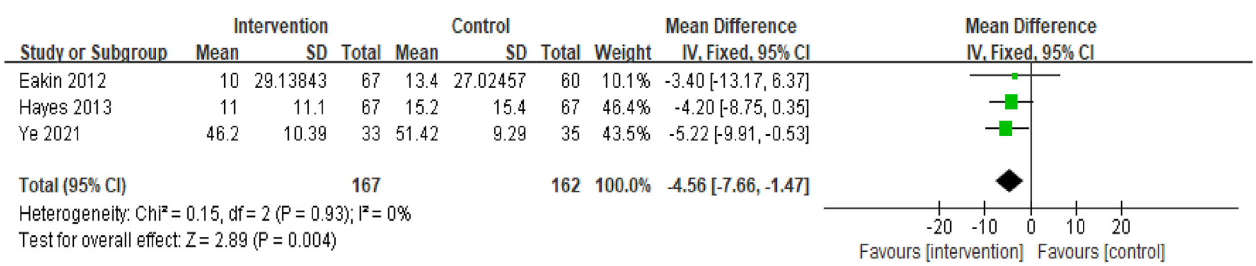

Fig. 7. Forest plot of the effect of telehealth-based exercise intervention on upper body function.

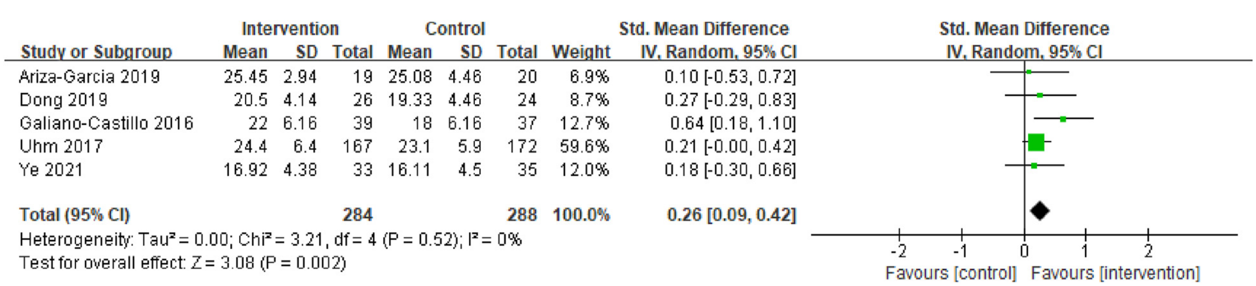

Fig. 8. Forest plot of the effect of telehealth-based exercise intervention on upper muscle strength.

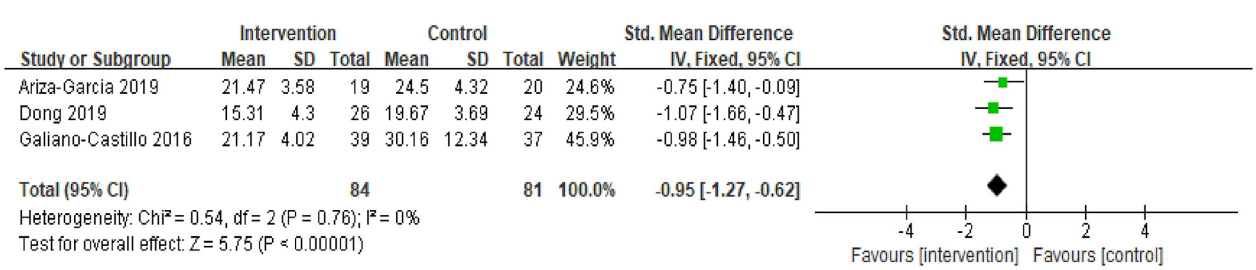

Fig. 9. Forest plot of the effect of telehealth-based exercise intervention on lower muscle strength.

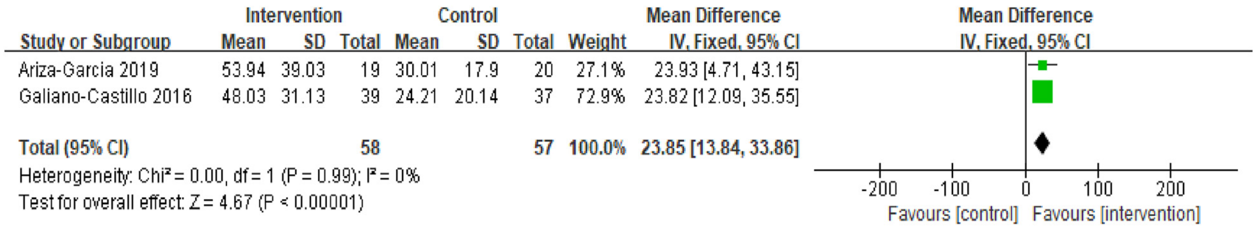

Fig. 10. Forest plot of the effect of telehealth-based exercise intervention on abdominal muscle strength.

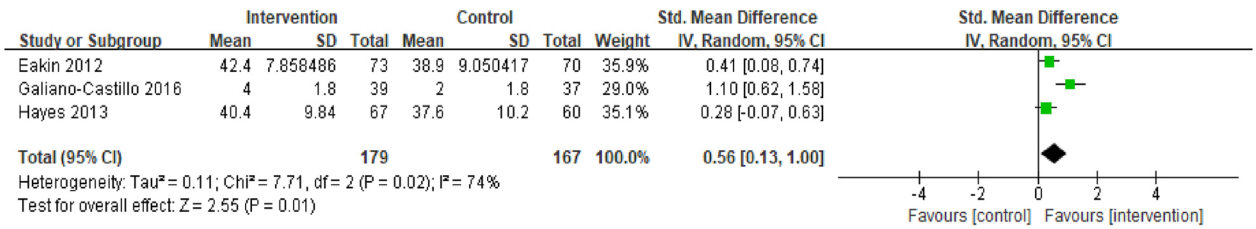

Fig. 11. Forest plot of the effect of telehealth-based exercise intervention on fatigue.

Scale-revised -.[39] Given the between-study homogeneity ($P = 0.02$, $I^2 = 74\%$), we used a random-effect model to calculate the SMD effect size. The result revealed that telehealth could alleviate patients' fatigue, with a statistical difference (SMD = 0.56, 95% CI 0.13 to 1.00, $P = 0.01$; Fig. 11).

Pain

Two studies, which encompassed 210 participants, reported pain. Pain was measured by using the Brief Pain Inventory and the Neuropathic Pain Scale.[34,39] Given the between-study homogeneity ($P = 0.003$, $I^2 = 89\%$), we used a random-effect model to calculate the SMD effect size. The result revealed that pain did not differ between intervention and control groups (SMD = −0.28, 95% CI −1.13 to 0.57, $P = 0.51$; Fig. 12).

Quality of life

Five trials involving 742 participants reported the outcome of QoL. The scales used in these trials can be categorized into the cancer-specific QoL scale (eg., EORTC QLQ-C30),[39,41] BC-specific QoL scale (eg., the Functional Assessment of Cancer Therapy-Breast [FACT-B+4] questionnaire),[33,34] and general QoL scale (eg., the 36-item Short Form Health Survey).[36] The effect measure (SMD) was selected because of the different measurement scales used in these studies. Moderate heterogeneity was found among the studies ($P = 0.09$, $I^2 = 51\%$). Thus, we used the random-effect model to summarize the mean effect size. The result showed that telehealth-based exercise intervention could significantly increase the QoL score related to BC (SMD = 0.26, 95% CI 0.04 to 0.49, $P = 0.02$; Fig. 13).

Discussion

This systematic review and meta-analysis synthesized existing literature on BC telehealth-based exercise intervention and provided a comprehensive overview of the effects of interventions that could be used as a foundation for a personalized telehealth exercise intervention in clinical practice. To our knowledge, this systematic review and meta-analysis is the first to examine the effect of telehealth-based exercise intervention in patients with BC. Nine RCTs ($n = 1127$) were included in the review. Based on the main findings, telehealth-based exercise intervention is effective, particularly in improving PA, aerobic capacity, upper body function and muscle strength, fatigue, and QoL. However, certain

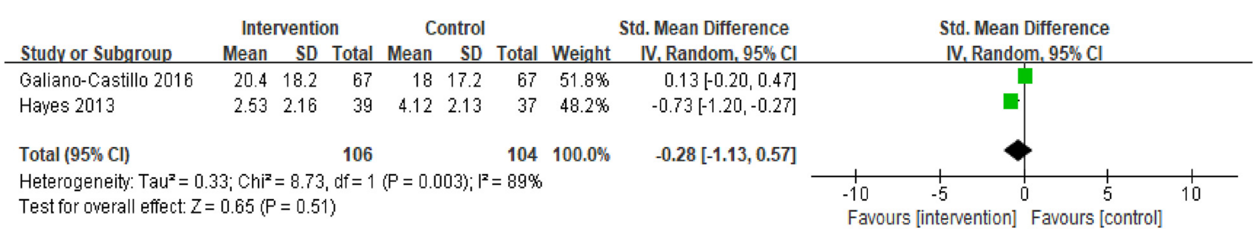

Fig. 12. Forest plot of the effect of telehealth-based exercise intervention on pain.

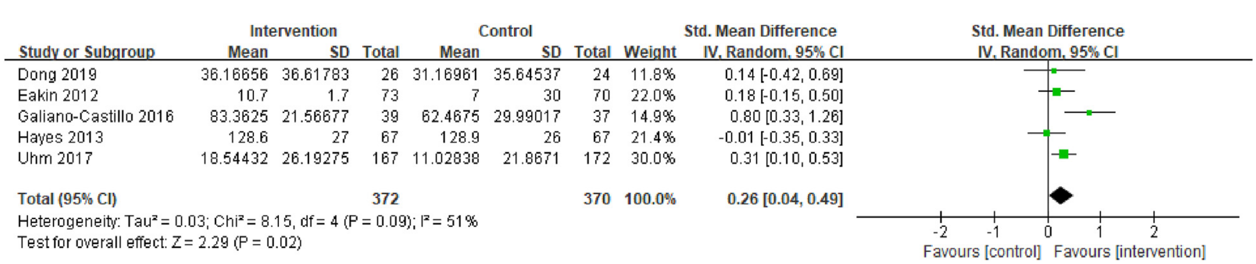

Fig. 13. Forest plot of the effect of telehealth-based exercise intervention on QoL.

evidence of heterogeneity is observed among studies. The effect of telehealth technology characteristics on intervention delivery and effectiveness warrants further consideration.

Methodological quality of included studies

Only RCTs were included to improve the quality of this meta-analysis, and quality assessment was performed in accordance with the Cochrane risk of bias tool. All included studies were determined with a low risk of bias in allocation concealment, selective reporting, and other bias because allocation concealment methods and outcome measure reporting were described in detail. Five studies were graded as unclear risk of bias because they did not comprehensively report the randomization methods in random sequence generation. As for incomplete outcome data, most studies were graded as low risk of bias and low dropout rates, and only one study had incomplete outcome data because the attrition rate was more than 30%.[38] However, of the nine trials, only one study met the criterion of the blinding of participants and personnel indicating low risk of bias, which may overestimate the intervention effect.[33] For blinding outcome assessment, six studies exhibited an unclear risk of bias because of indistinct designs. Inadequate blinding may differ the measured results from the actual value and detected bias. Based on these findings, the methodological quality of the summarized evidence ranged from low to moderate. Consequently, in further research, the creation of random sequence generation and blinding of participants, personnel, and researchers should emphasize outcome assessment to reach plausible conclusions.

Working mechanisms of exercise interventions

Existing studies have shown the mechanisms of exercise intervention through the following points: First, sex steroid hormones have a powerful mitogenic and proliferative effect on breast tissue, and elevated estrogen levels in the circulation stimulate the growth of BC cells. In addition, PA can reduce the conversion capacity of androgens to estrogens and lower the estrogen levels in the circulation.[43,44] Second, anabolic insulin and insulin-like growth factor promote tumor growth by stimulating cell growth and inhibiting apoptosis via the insulin receptor in breast tissue. Regular PA can reduce insulin and insulin resistance, thereby decreasing the BC relapse risk.[44]

Effect of telehealth-based exercise interventions

In this systematic review and meta-analysis, nine RCTs were included. These included studies provided telehealth-based exercise intervention for patients with BC, and the pooled results demonstrated that telehealth-based exercise intervention was associated with higher PA level, more robust aerobic capacity, upper body function and muscle strength, less fatigue, and higher QoL scores compared with waitlist control, standard education, and usual care.

With improved medical treatment, long-term survival with cancer has become the everyday life of patients with BC, but they still face physical, psychological, QoL, and other challenges. Regular PA can reduce mortality and BC recurrence risk, manage symptoms, and improve QoL, which was consistent with previous studies.[45,46] However, from pre-diagnosis to post-treatment in women with BC, PA could reduce by an average of 2 h per week.[47] Based on our findings, telehealth-based exercise intervention could remarkably increase the PA level of patients with BC, which was consistent with a previous similar systematic review.[48] This result may cause patients' high compliance and satisfaction because telemedicine provides an opportunity to break down the constraints of time and distance between healthcare providers and patients, which has a vivid form, efficiency, and convenience.[49–52] Through literature review, we found that the wearable technology-based intervention remarkably changed the sedentary behavior of patients with BC probably because wearable technology monitor can monitor patients' activities in real time. In addition, sedentary behavior could increase the risk of cancer.[53] Preliminary evidence suggests that being sedentary may be negatively associated with obesity, fatigue, and QoL in BC survivors.[54–56] Considering that only one study was included, the result could not be synthesized; thus, further research is necessary.

In addition, our study showed that telehealth-based exercise intervention was effective in improving aerobic capacity, muscle strength, and upper body function. This result may be due to the increased PA, thereby improving physical performance. Aerobic physical activities can increase aerobic capacity (e.g., walking, jogging, cycling, and swimming), and non-aerobic physical activities can improve muscle strength, elasticity, and endurance.[57] Lu et al.[58] revealed that appropriate resistance training could also alleviate adverse muscles or bone symptoms. Furthermore, some patients with BC suffer from cancer therapeutics-related cardiac dysfunction because of the utilization of an antineoplastic drug. Gilchrist et al.[59] suggested that short-term aerobic and resistance exercise could improve aerobic capacity in cancer survivors, thereby reducing cardiovascular complication incidence and all-cause mortality. A series of enhanced physical conditions has also led to better QoL for patients with BC. In addition, telehealth-based exercise interventions relieve fatigue and positively affect QoL. This result was consistent with the study of Keikha et al.[48] Telehealth-based exercise intervention is a new program that directly improve not only PA levels but also the physical condition, thereby reducing treatment-related side effects and increasing QoL scores.

Although no significant difference in anthropometric and body composition was found between the two groups, telehealth-based exercise intervention tended to lower BMI (MD $= -0.11$, 95% CI -0.78 to 0.56, $P = 0.75$), which was inconsistent with a study in the USA.[60] This result was due to the following reasons: first, the included studies had a short follow-up and low-to-moderate level of exercise; second, the body composition cannot be changed within a short period. Pagola et al.[61] showed that a training program, including high-intensity exercises, could shorten waist circumference; therefore, a high-intensity exercise program is necessary to improve central adiposity. In addition, although our study indicated no significant difference in pain between the two groups, telehealth-based exercise intervention tended to relieve pain (SMD $= -0.28$, 95% CI -1.13 to 0.57, $P = 0.51$); this result was inconsistent with a previous study performed by Fu et al.[62] Nevertheless, musculoskeletal pain could be relieved in patients with BC by a 12-month remotely delivered exercise intervention.[63] Patients with BC experienced treatment-induced chronic pain to a large extent.[64] Therefore, RCTs with a long-period intervention are necessary to confirm the effectiveness.

Forms of telehealth-based exercise interventions

With the development of electronic communication, various telehealth interventions have emerged. Nevertheless, our results demonstrated that the widely studied type of telehealth intervention in patients with BC was Internet-based telehealth, followed by telephone-based, which was in agreement with the result of Chen et al.[65] Previous research indicates that about 50% of patients with BC already use the Internet for information seeking; therefore, Internet-based telemedicine is feasible and prospering.[66] The web-based online system can provide an informative and professional communication platform for healthcare providers and patients. On the one hand, healthcare staff can monitor the changes in patients' conditions and analyze data; on the other hand, patients can receive timely and personalized exercise guidance and care messages. As another finding of this study, multiple communication technologies were used to combine motion interventions, such as Internet combined with social media software and motion capture technology, telephone combined with a pedometer, and wearable technology. Therefore, we should focus on the fundamental role of the Internet and telephone in information delivery while not neglecting the part of other emerging technologies in data monitoring and analysis. In the future, researchers may consider innovative ways to integrate multiple technologies for interventions, thereby increasing compliance and improving effectiveness.

Compared with previously published studies,[67,68] we have observed the unique superiority of wearable devices and motion capture technology in telehealth-based exercise interventions. Wearable remote devices are important to achieve remote medical monitoring, which has good biocompatibility and accessibility, and it can be applied in various environments.[69] Motion capture technology can capture patient's body movements and perform quantitative analysis and evaluation, which is beneficial for healthcare professionals to view individual's exercise completion and rehabilitation on time to give appropriate guidance.[70] Based on markerless motion capture technology, patients are not subjected to experimental equipment, and they demonstrate their natural behavior, which is an advantage that wearable technology does not have.[71] With the booming technology, we can explore more emerging technologies for telehealth applications, such as virtual reality and interactive voice response systems.[72,73] Given the limited number of included studies and non-uniform outcome indicators, our study did not perform subgroup analysis that would allow us to determine the effective form of intervention. This inadequacy must be refined in future studies.

Limitations

Some strengths are identified in this systematic review. First, we used a combination of MeSH terms and keywords that covered BC, telehealth, and exercise intervention to search 11 primary electronic databases and minimize the possibilities of publication bias. Second, only RCTs were included in our study. Despite these positive aspects, the present study has some limitations. First, the methodological quality of the included studies was not optimal, and most studies had risks of performance, selection, and detection bias. Second, studies varied in sample sizes and components, duration, and delivery approaches of telehealth-based exercise intervention, leading to high heterogeneity. Third, although we used a comprehensive search strategy, the data for some studies were incomplete, and we could not find the full-text of some studies. Moreover, some unpublished articles might not be included. Fourth, only studies published in English and Chinese were considered, which indicates that relevant studies published in other languages were excluded.

Implications for nursing practice and further research

The treatment and recovery of BC is a long-term and dynamic process, and patients will have diverse care needs during the prolonged treatment and recovery process. Based on our findings, the telehealth-based exercise intervention positively and significantly affects patients' PA, physical performance, fatigue, and QoL. Exercise intervention is based on telehealth technology, which is convenient, accessible, interactive, and efficient. Therefore, telehealth-based exercise intervention is worthy of clinical use, and it should be regarded as a crucial component of comprehensive treatment for patients with BC. Meanwhile, nursing practitioners should pay attention to data security in the practical telehealth application.

Several recommendations for further research must be addressed with care: (1) Future research should focus on finding the optimal telehealth-based exercise intervention approach for patients with BC with different characteristics. (2) Future studies should explore the effects of telehealth-based exercise interventions on sedentary behavior and other body movements in patients with BC. (3) Future research should explore and determine effective and acceptable type of interventions based on different forms of telehealth interventions, particularly emerging technologies. (4) Future studies should conduct cost–benefit analysis to consider vital factors determining whether telehealth-based interventions can be fully promoted.

Conclusions

Telehealth-based exercise intervention is superior to usual care in patients with BC to improve PA, aerobic capacity, body function, muscle strength, and QoL, with less fatigue. Although these findings should be recognized cautiously because of between-study heterogeneity, further RCTs of telehealth-based exercise intervention are warranted. Furthermore, telehealth-based exercise intervention can overcome travel restrictions caused by the COVID-19 pandemic and promote accessibility to health services in rural and remote areas, thereby promoting its great application potential.

Author contributions

Yueyang Peng: Methodology; Formal analysis; Writing – Original Draft. **Kun Zhang:** Conceptualization; Methodology. **Luyao Wang:** Validation. **Yunyun Peng:** Data curation. **Zixuan Liu:** Data curation. **Li Liu:** Writing – Review & Editing. **Yang Luo:** Visualization. **Can Gu:** Conceptualization; Supervision; Project administration; Funding acquisition.

Declaration of competing interest

None declared.

Funding

This study was supported by China Medical Board (Grant No. #20–369), the National Natural Science Foundation of China (Grant No. 81703084), the Natural Science Foundation of Hunan Province, China (Grant No. 2022JJ30774) and the Hunan Women's Federation (Grant No. 19WTB03).

Registration

The study protocol was registered in PROSPERO (CRD42022326484). This systematic review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines[74].

Supplementary material

To access the supplementary material accompanying this article, visit the online version of the *Journal of the Society for Cardiovascular Angiography & Interventions* at https://doi.org/10.1016/j.apjon.2022.100117.

References

1. Sung H, Ferlay J, Siegel RL, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries [Journal Article] *CA Cancer J Clin*. 2021;71(3):209–249.
2. Yoon TI, Hwang UK, Kim ET, et al. Survival improvement in hormone-responsive young breast cancer patients with endocrine therapy [Journal Article] *Breast Cancer Res Treat*. 2017;165(2):311–320.
3. Juvet LK, Thune I, Elvsaas I, et al. The effect of exercise on fatigue and physical functioning in breast cancer patients during and after treatment and at 6 months follow-up: a meta-analysis [Journal Article; Meta-Analysis; Review; Systematic Review] *Breast*. 2017;33:166–177.
4. de Rezende LF, Francisco VE, Franco RL. Telerehabilitation for patients with breast cancer through the COVID-19 pandemic [Letter] *Breast Cancer Res Treat*. 2021; 185(1):257–259.
5. Tran T, Jung SY, Lee EG, et al. Long-term trajectory of postoperative health-related quality of life in young breast cancer patients: a 15-year follow-up study [Journal Article] *J Cancer Surviv*. 2022. In press, Online ahead of print 2022 March 12.
6. Archangelo S, Sabino NM, Veiga DF, Garcia EB, Ferreira LM. Sexuality, depression and body image after breast reconstruction [Comparative Study; Journal Article] *Clinics (Sao Paulo)*. 2019;74:e883.
7. Li X, Wang H, Xu HP, et al. Menopausal symptoms and quality of life of hormone receptor positive breast cancer patients at different endocrine therapy time [Journal Article] *Zhonghua Zhong Liu Za Zhi*. 2020;42(1):55–60.
8. Abrahams H, Gielissen M, Schmits IC, Verhagen C, Rovers MM, Knoop H. Risk factors, prevalence, and course of severe fatigue after breast cancer treatment: a meta-analysis involving 12 327 breast cancer survivors [Journal Article; Meta-Analysis; Research Support, Non-U.S. Gov't; Review] *Ann Oncol*. 2016;27(6): 965–974.
9. Klassen O, Schmidt ME, Ulrich CM, et al. Muscle strength in breast cancer patients receiving different treatment regimes [Journal Article; Randomized Controlled Trial] *J Cachexia Sarcopenia Muscle*. 2017;8(2):305–316.

10. Irwin ML, McTiernan A, Baumgartner RN, et al. Changes in body fat and weight after a breast cancer diagnosis: influence of demographic, prognostic, and lifestyle factors [Journal Article; Research Support, Non-U.S. Gov't; Research Support, U.S. Gov't, P.H.S.] *J Clin Oncol*. 2005;23(4):774–782.
11. Oei SL, Thronicke A, Matthes H, Schad F. Evaluation of the effects of integrative non-pharmacological interventions on the internal coherence and resilience of breast cancer patients [Journal Article] *Support Care Cancer*. 2021;29(3):1413–1421.
12. Biglia N, Bounous VE, De Seta F, Lello S, Nappi RE, Paoletti AM. Non-hormonal strategies for managing menopausal symptoms in cancer survivors: an update [Journal Article; Review] *Ecancermedicalscience*. 2019;13:909.
13. Dieli-Conwright CM, Courneya KS, Demark-Wahnefried W, et al. Effects of aerobic and resistance exercise on metabolic syndrome, sarcopenic obesity, and circulating biomarkers in overweight or obese survivors of breast cancer: a randomized controlled trial [Journal Article; Randomized Controlled Trial; Research Support, N.I.H., Extramural] *J Clin Oncol*. 2018;36(9):875–883.
14. Holmes MD, Chen WY, Feskanich D, Kroenke CH, Colditz GA. Physical activity and survival after breast cancer diagnosis [Journal Article; Research Support, U.S. Gov't, P.H.S.] *JAMA*. 2005;293(20):2479–2486.
15. Spei ME, Samoli E, Bravi F, La Vecchia C, Bamia C, Benetou V. Physical activity in breast cancer survivors: a systematic review and meta-analysis on overall and breast cancer survival [Journal Article; Meta-Analysis; Systematic Review] *Breast*. 2019;44: 144–152.
16. McTiernan A, Friedenreich CM, Katzmarzyk PT, et al. Physical activity in cancer prevention and survival: a systematic review [Journal Article; Systematic Review] *Med Sci Sports Exerc*. 2019;51(6):1252–1261.
17. Bethany, Tennant, Isabela, Ribeiro-Lucas, Alison, Vaux-Bjerke, Katrina, & Piercy Andrea Torres. Umbrella and systematic review methodology to support the 2018 physical activity guidelines advisory committee. *J Phys Activ Health*. 2018. Epub 2018 Oct 18.
18. Campbell KL, Winters-Stone KM, Wiskemann J, et al. Exercise guidelines for cancer survivors: Consensus statement from international multidisciplinary roundtable [Journal Article; Practice Guideline; Research Support, Non-U.S. Gov't] *Med Sci Sports Exerc*. 2019;51(11):2375–2390.
19. Hasenoehrl T, Keilani M, Palma S, Crevenna R. Resistance exercise and breast cancer related lymphedema - a systematic review update [Journal Article; Systematic Review] *Disabil Rehabil*. 2020;42(1):26–35.
20. Boing L, Vieira M, Moratelli J, Bergmann A, Guimarães A. Effects of exercise on physical outcomes of breast cancer survivors receiving hormone therapy - a systematic review and meta-analysis [Journal Article; Meta-Analysis; Systematic Review] *Maturitas*. 2020;141:71–81.
21. Panchik D, Masco S, Zinnikas P, et al. Effect of exercise on breast cancer-related lymphedema: what the lymphatic surgeon needs to know [Journal Article; Meta-Analysis; Systematic Review] *J Reconstr Microsurg*. 2019;35(1):37–45.
22. Rawstorn JC, Gant N, Direito A, Beckmann C, Maddison R. Telehealth exercise-based cardiac rehabilitation: a systematic review and meta-analysis [Journal Article; Meta-Analysis; Review; Systematic Review] *Heart*. 2016;102(15):1183–1192.
23. Al SQ, Al-Ghaith T, Alshehri A, et al. The capacity of primary health care facilities in Saudi Arabia: infrastructure, services, drug availability, and human resources [Journal Article] *BMC Health Serv Res*. 2021;21(1):365.
24. Tuckson RV, Edmunds M, Hodgkins ML. Telehealth [Journal Article] *N Engl J Med*. 2017;377(16):1585–1592.
25. O'Connor M, Bowles KH. Telehealth and mHealth [Editorial] *Res Nurs Health*. 2021; 44(1):3–4.
26. Nelson R. Telemedicine and telehealth: the potential to improve rural access to care [Journal Article] *Am J Nurs*. 2017;117(6):17–18.
27. Mann DM, Chen J, Chunara R, Testa PA, Nov O. COVID-19 transforms health care through telemedicine: evidence from the field [Journal Article; Research Support, U.S. Gov't, Non-P.H.S.] *J Am Med Inf Assoc*. 2020;27(7):1132–1135.
28. Ohannessian R, Duong TA, Odone A. Global telemedicine implementation and integration within health systems to fight the COVID-19 pandemic: a call to action [Journal Article] *JMIR Public Health Surveill*. 2020;6(2), e18810.
29. Johnson BA, Lindgren BR, Blaes AH, et al. The new normal? Patient satisfaction and usability of telemedicine in breast cancer care [Journal Article] *Ann Surg Oncol*. 2021;28(10):5668–5676.
30. Maguire R, McCann L, Kotronoulas G, et al. Real time remote symptom monitoring during chemotherapy for cancer: European multicentre randomised controlled trial (eSMART) [Journal Article; Multicenter Study; Randomized Controlled Trial; Research Support, Non-U.S. Gov't] *BMJ*. 2021;374:n1647.
31. Odynets T, Briskin Y, Todorova V. Effects of different exercise interventions on quality of life in breast cancer patients: a randomized controlled trial [Journal Article; Randomized Controlled Trial] *Integr Cancer Ther*. 2019;18, 1871099030.
32. Higgins J, Green S (updated March 2011) [Z]. In: *Cochrane Handbook for Systematic Reviews of interventions Version 5.1.0*. 2011.
33. Eakin EG, Lawler SP, Winkler EA, Hayes SC. A randomized trial of a telephone-delivered exercise intervention for non-urban dwelling women newly diagnosed with breast cancer: exercise for health [Journal Article; Randomized Controlled Trial; Research Support, Non-U.S. Gov't] *Ann Behav Med*. 2012;43(2):229–238.
34. Hayes SC, Rye S, Disipio T, et al. Exercise for health: a randomized, controlled trial evaluating the impact of a pragmatic, translational exercise intervention on the quality of life, function and treatment-related side effects following breast cancer [Journal Article; Randomized Controlled Trial; Research Support, Non-U.S. Gov't] *Breast Cancer Res Treat*. 2013;137(1):175–186.
35. Lynch BM, Nguyen NH, Moore MM, et al. A randomized controlled trial of a wearable technology-based intervention for increasing moderate to vigorous physical activity and reducing sedentary behavior in breast cancer survivors: the ACTIVATE Trial [Journal Article; Randomized Controlled Trial; Research Support, Non-U.S. Gov't] *Cancer*. 2019;125(16):2846–2855.
36. Dong X, Yi X, Gao D, et al. The effects of the combined exercise intervention based on internet and social media software (CEIBISMS) on quality of life, muscle strength and cardiorespiratory capacity in Chinese postoperative breast cancer patients:a randomized controlled trial [Journal Article; Randomized Controlled Trial] *Health Qual Life Outcome*. 2019;17(1):109.
37. Ye Xiaolu, Xu Jingjuan, Gao Xuejuan, Cui Qing, Wu Zhishui, Xiaoying S. Application of rehabilitation program based on motion capture technology to home-residing post-surgical breast cancer patients. *Int J Nurs Sci*. 2021;36(13):86–90.
38. Ariza-Garcia A, Lozano-Lozano M, Galiano-Castillo N, Postigo-Martin P, Arroyo-Morales M, Cantarero-Villanueva I. A web-based exercise system (e-CuidateChemo) to counter the side effects of chemotherapy in patients with breast cancer: randomized controlled trial [Journal Article; Randomized Controlled Trial; Research Support, Non-U.S. Gov't] *J Med Internet Res*. 2019;21(7), e14418.
39. Galiano-Castillo N, Cantarero-Villanueva I, Fernández-Lao C, et al. Telehealth system: a randomized controlled trial evaluating the impact of an internet-based exercise intervention on quality of life, pain, muscle strength, and fatigue in breast cancer survivors [Comparative Study; Journal Article; Randomized Controlled Trial] *Cancer*. 2016;122(20):3166–3174.
40. Hatchett A, Hallam JS, Ford MA. Evaluation of a social cognitive theory-based email intervention designed to influence the physical activity of survivors of breast cancer [Journal Article; Randomized Controlled Trial] *Psychooncology*. 2013;22(4): 829–836.
41. Uhm KE, Yoo JS, Chung SH, et al. Effects of exercise intervention in breast cancer patients: is mobile health (mHealth) with pedometer more effective than conventional program using brochure? [Clinical Trial; Journal Article; Multicenter Study; Randomized Controlled Trial; Research Support, Non-U.S. Gov't] *Breast Cancer Res Treat*. 2017;161(3):443–452.
42. Nguyen NH, Vallance JK, Buman MP, et al. Effects of a wearable technology-based physical activity intervention on sleep quality in breast cancer survivors: the ACTIVATE Trial [Journal Article; Randomized Controlled Trial; Research Support, Non-U.S. Gov't] *J Cancer Surviv*. 2021;15(2):273–280.
43. Coyle YM. Physical activity as a negative modulator of estrogen-induced breast cancer [Journal Article; Research Support, Non-U.S. Gov't; Review] *Cancer Causes Control*. 2008;19(10):1021–1029.
44. Ogunleye AA, Holmes MD. Physical activity and breast cancer survival. *Breast Cancer Res*. 2009;11(5):1–3.
45. Geng Z, Wu F, Zhang Y, et al. Mobile physical activity intervention for breast cancer patients during chemotherapy [Journal Article] *Stud Health Technol Inform*. 2018; 250:236.
46. Peterson LL, Ligibel JA. Physical activity and breast cancer: an opportunity to improve outcomes [Journal Article; Review] *Curr Oncol Rep*. 2018;20(7):50.
47. Irwin ML, Crumley D, McTiernan A, et al. Physical activity levels before and after a diagnosis of breast carcinoma: the health, eating, activity, and lifestyle (HEAL) study [Journal Article; Research Support, U.S. Gov't, P.H.S.] *Cancer*. 2003;97(7): 1746–1757.
48. Keikha L, Maserat E, Mohammadzadeh Z. Telerehabilitation and monitoring physical activity in patient with breast cancer: systematic review [Journal Article; Review] *Iran J Nurs Midwifery Res*. 2022;27(1):8–17.
49. Hsieh HL, Tsai CH, Chih WH, Lin HH. Factors affecting success of an integrated community-based telehealth system [Journal Article] *Technol Health Care*. 2015; 23(suppl 2):S189–S196.
50. Bokolo AJ. Exploring the adoption of telemedicine and virtual software for care of outpatients during and after COVID-19 pandemic [Journal Article; Review] *Ir J Med Sci*. 2021;190(1):1–10.
51. Almathami H, Win KT, Vlahu-Gjorgievska E. Barriers and facilitators that influence telemedicine-based, real-time, online consultation at patients' homes: systematic literature review [Journal Article; Research Support, Non-U.S. Gov't; Systematic Review] *J Med Internet Res*. 2020;22(2), e16407.
52. Chung IY, Jung M, Lee SB, et al. An assessment of physical activity data collected via a smartphone app and a smart band in breast cancer survivors: observational study [Journal Article; Research Support, Non-U.S. Gov't] *J Med Internet Res*. 2019;21(9), 13463.
53. Friedenreich CM, Ryder-Burbidge C, McNeil J. Physical activity, obesity and sedentary behavior in cancer etiology: epidemiologic evidence and biologic mechanisms [Journal Article; Review] *Molecular Oncology*. 2021;15(3):790–800.
54. Lynch BM, Dunstan DW, Healy GN, Winkler E, Eakin E, Owen N. Objectively measured physical activity and sedentary time of breast cancer survivors, and associations with adiposity: findings from NHANES (2003-2006) [Journal Article; Research Support, Non-U.S. Gov't] *Cancer Causes Control*. 2010;21(2):283–288.
55. Rogers LQ, Markwell SJ, Courneya KS, McAuley E, Verhulst S. Physical activity type and intensity among rural breast cancer survivors: patterns and associations with fatigue and depressive symptoms [Journal Article; Research Support, N.I.H., Extramural; Research Support, Non-U.S. Gov't] *J Cancer Surviv*. 2011;5(1):54–61.
56. Phillips SM, Awick EA, Conroy DE, Pellegrini CA, Mailey EL, McAuley E. Objectively measured physical activity and sedentary behavior and quality of life indicators in survivors of breast cancer [Journal Article; Research Support, N.I.H., Extramural; Research Support, Non-U.S. Gov't] *Cancer*. 2015;121(22):4044–4052.
57. Brdareski Z, Djurović A, Susnjar S, et al. Physical activity and maximal aerobic capacity in breast cancer survivors–why this is important [Journal Article; Review]. Vojnosanit Pregl, 71(1), 66-72.
58. Lu G, Zheng J, Zhang L. The effect of exercise on aromatase inhibitor-induced musculoskeletal symptoms in breast cancer survivors: a systematic review and meta-

analysis [Journal Article; Meta-Analysis; Systematic Review] *Support Care Cancer*. 2020;28(4):1587–1596.
59. Gilchrist SC, Barac A, Ades PA, et al. Cardio-oncology rehabilitation to manage cardiovascular outcomes in cancer patients and survivors: a scientific statement from the American Heart Association [Journal Article; Practice Guideline] *Circulation*. 2019;139(21):e997–e1012.
60. Ligibel JA, Partridge A, Giobbie-Hurder A, et al. Physical and psychological outcomes among women in a telephone-based exercise intervention during adjuvant therapy for early stage breast cancer [Journal Article] *J Womens Health (Larchmt)*. 2010; 19(8):1553–1559.
61. Pagola I, Morales JS, Alejo LB, et al. Concurrent exercise interventions in breast cancer survivors with cancer-related fatigue [Journal Article; Randomized Controlled Trial] *Int J Sports Med*. 2020;41(11):790–797.
62. Fu MR, Axelrod D, Guth AA, et al. A web- and mobile-based intervention for women treated for breast cancer to manage chronic pain and symptoms related to lymphedema: results of a randomized clinical trial [Journal Article] *JMIR Cancer*. 2022;8(1), e29485.
63. Reeves MM, Terranova CO, Winkler E, et al. Effect of a remotely delivered weight loss intervention in early-stage breast cancer: randomized controlled trial [Journal Article; Randomized Controlled Trial] *Nutrients*. 2021;13(11).
64. Wang K, Yee C, Tam S, et al. Prevalence of pain in patients with breast cancer post-treatment: a systematic review [Journal Article; Systematic Review] *Breast*. 2018;42: 113–127.
65. Chen YY, Guan BS, Li ZK, Li XY. Effect of telehealth intervention on breast cancer patients' quality of life and psychological outcomes: a meta-analysis [Journal Article; Meta-Analysis] *J Telemed Telecare*. 2018;24(3):157–167.
66. van den Berg SW, Gielissen MF, Custers JA, van der Graaf WT, Ottevanger PB, Prins JB. BREATH: web-based self-management for psychological adjustment after primary breast cancer–results of a multicenter randomized controlled trial [Journal Article; Multicenter Study; Randomized Controlled Trial; Research Support, Non-U.S. Gov't] *J Clin Oncol*. 2015;33(25):2763–2771.
67. Li J, Liu Y, Jiang J, Peng X, Hu X. Effect of telehealth interventions on quality of life in cancer survivors: a systematic review and meta-analysis of randomized controlled trials [Journal Article; Meta-Analysis; Systematic Review] *Int J Nurs Stud*. 2021;122, 103970.
68. Dorri S, Asadi F, Olfatbakhsh A, Kazemi A. A Systematic Review of Electronic Health (eHealth) interventions to improve physical activity in patients with breast cancer [Journal Article; Systematic Review] *Breast Cancer*. 2020;27(1):25–46.
69. Sana F, Isselbacher EM, Singh JP, Heist EK, Pathik B, Armoundas AA. Wearable devices for ambulatory cardiac monitoring: JACC state-of-the-art review [Journal Article; Research Support, N.I.H., Extramural; Research Support, Non-U.S. Gov't; Review] *J Am Coll Cardiol*. 2020;75(13):1582–1592.
70. Jiang Y. Combination of wearable sensors and internet of things and its application in sports rehabilitation. *Comput Commun*. 2019;150.
71. Yoshimura M, Kitazawa M, Maeda Y, Mimura M, Tsubota K, Kishimoto T. Smartphone viewing distance and sleep: an experimental study utilizing motion capture technology [Journal Article] *Nat Sci Sleep*. 2017;9:59–65.
72. Zhou Z, Li J, Wang H, Luan Z, Li Y, Peng X. Upper limb rehabilitation system based on virtual reality for breast cancer patients: development and usability study [Journal Article; Research Support, Non-U.S. Gov't] *PLoS One*. 2021;16(12), e261220.
73. Ganjali R, Taherzadeh Z, Ghorban SM, et al. Effect of an interactive voice response system on self-management in kidney transplant recipients: protocol for a randomized controlled trial [Journal Article; Randomized Controlled Trial] *Medicine (Baltimore)*. 2019;98(6), e14291.
74. Page MJ, Mckenzie J, Bossuyt P, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372(n71).