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Prehabilitation in Patients Undergoing Breast Cancer Surgery: A Scoping Review

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Abstract: ***Objective:*** *To conduct a scoping review of preoperative prehabilitation studies in breast cancer patients, and to provide reference for constructing standardized prehabilitation protocols.* ***Methods:*** *A systematic search was conducted across Cochrane Library, PubMed, Embase, Web of Science, Chinese Biomedical Literature Database (CBM), China National Knowledge Infrastructure (CNKI), Wanfang Data, and VIP Chinese Science and Technology Periodicals Database. The search timeframe spanned from database inception to January 1, 2026. Two researchers independently completed literature screening and data extraction.* ***Results:*** *A total of 16 articles were included. Preoperative prehabilitation interventions primarily encompassed multimodal exercise training, individualized nutritional support, and psychological-behavioral interventions. Intervention teams were predominantly multidisciplinary in composition, with intervention settings spanning both hospital and home environments. Evaluation indicators included feasibility metrics, physical function and fitness indicators, quality of life and symptom burden indicators, breast cancer-specific outcome indicators, tumor biology/molecular mechanism indicators, psychosocial and behavioral indicators, and postoperative clinical outcomes.* ***Conclusion:*** *Currently, breast cancer prehabilitation is transitioning from single-modal to multimodal approaches; however, nutritional and psychological interventions remain insufficiently covered, and intervention intensity, duration, and implementation models have yet to be standardized. Multimodal prehabilitation remains in its nascent stage. Preoperative prehabilitation protocols for breast cancer patients urgently require optimization and standardization. Future efforts should strengthen patient adherence monitoring, integrate intelligent technologies, extend prehabilitation time windows, focus on precise strategies for special populations, and conduct large-sample, multicenter clinical trials to deeply explore the effectiveness and feasibility of multimodal prehabilitation.*

Keywords: Breast cancer, Prehabilitation, Nursing, Scoping review.

1. Introduction

Breast cancer represents the most frequently diagnosed malignancy among women globally, and constitutes one of the principal causes of cancer-related mortality [1]. The latest data from the World Health Organization indicate that its prevalence is rising, having surpassed lung cancer to become the most common cancer worldwide [2, 3]. At present, surgical intervention remains one of the most critical therapeutic modalities for breast cancer, serving as the primary treatment approach for long-term patient benefit [4]. Breast cancer surgery demands high technical proficiency, and is associated with elevated postoperative complication rates, presenting substantial challenges to postoperative recovery [5]. Concurrently, tumor-induced physiological and metabolic disturbances may further exacerbate patients' preoperative nutritional status, thereby exerting deleterious effects on postoperative recovery trajectories and long-term survival quality [6]. Consequently, there is an urgent imperative to explore novel paradigms to accelerate postoperative recovery in breast cancer patients.

Prehabilitation represents a multimodal, multidisciplinary preoperative optimization strategy that has evolved from the Enhanced Recovery After Surgery (ERAS) conceptual framework, and has progressively emerged as a research focal point in perioperative management. This paradigm implements multidimensional intervention protocols for patients during the preoperative period, encompassing nutritional support, exercise training, and psychological intervention, to substantially enhance patients' functional reserve and capacity to withstand surgical stress, thereby optimizing surgical outcomes, accelerating postoperative recovery velocity, and achieving reductions in postoperative complications, postoperative hospitalization duration, and hospitalization costs [7]. Prehabilitation strategies maintain close interconnection with clinical nursing practice, having undergone extensive applied research and practical exploration within surgical domains and clinical nursing contexts [8]. Prehabilitation emphasizes interdisciplinary collaboration, establishing multidisciplinary teams comprising surgeons, rehabilitation therapists, nutritionists, and psychiatrists to integrate diverse evidence-based interventions and address the complex needs of breast cancer patients [9]. Nevertheless, specific intervention modalities, procedures, and temporal parameters of prehabilitation protocols for breast cancer patients currently exhibit considerable variation, with no unified intervention pathway yet established. This study employs scoping review methodology to elucidate the specific intervention contents, intervention effectiveness evaluation indicators, and existing deficiencies in prehabilitation application for breast cancer surgery patients, with the objective of providing evidence-based foundations for optimizing perioperative management in clinical nursing practice, and informing the design of standardized prehabilitation protocols for future research.

2. Materials and Methods

2.1 Formulation of Research Questions

Specific research questions were as follows: (1) What specific intervention contents are encompassed within prehabilitation for breast cancer surgery patients? (2) What evaluation indicators are employed to assess prehabilitation intervention

effectiveness? (3) What deficiencies currently exist in prehabilitation research and clinical application?

2.2 Literature Search Strategy

The following databases were searched: Cochrane Library, PubMed, Embase, Web of Science, Chinese Biomedical Literature Database (CBM), China National Knowledge Infrastructure (CNKI), Wanfang Data Knowledge Service Platform, and VIP Chinese Science and Technology Periodicals Database. Searches were conducted using combinations of subject headings and free-text terms within title, abstract, or subject fields. The search timeframe extended from database inception to January 1, 2026. Exemplifying the Chinese database search strategy using CNKI: SU=('breast cancer' + 'breast tumor' + 'mammary cancer' + 'breast carcinoma' + 'breast malignant tumor' + 'breast neoplasm' + 'mammary tumor') AND SU=('surgery' + 'surgical treatment' + 'surgical operation' + 'radical mastectomy for breast cancer' + 'resection surgery' + 'breast-conserving surgery' + 'modified radical mastectomy for breast cancer') AND SU=('prehabilitation' + 'prehabilitation nursing' + 'prehabilitation measures' + 'preoperative rehabilitation' + 'preoperative nursing' + 'preoperative nursing guidance' + 'preoperative exercise' + 'preoperative training' + 'preoperative exercise intervention' + 'preoperative exercise rehabilitation training' + 'preoperative nutrition' + 'preoperative nutrition management' + 'preoperative nutrition support' + 'preoperative nutrition intervention' + 'preoperative psychological therapy' + 'preoperative psychological intervention'). Exemplifying the English database search strategy using PubMed: #1 ("breast neoplasms" [Mesh Terms]) OR (malignant breast neoplasms [Mesh Terms]) OR (breast cancer [Title/Abstract]) OR (breast tumor [Title/Abstract]) OR (mammary cancer [Title/Abstract]) OR (cancer of breast [Title/Abstract]) OR (malignant neoplasm of breast [Title/Abstract]) OR (malignant tumor of breast [Title/Abstract]) OR (breast carcinoma [Title/Abstract]) OR (carcinoma, breast [Title/Abstract]); #2 ("Surgical Procedures, Operative" [MeSH Terms]) OR ("Mastectomy, Radical" [MeSH Terms]) OR ("Mastectomy, Modified Radical" [MeSH Terms]) OR ("Breast-Conserving Surgery" [MeSH Terms]) OR ("Breast Reconstruction" [MeSH Terms]) OR (surgery [Title/Abstract] OR surgical treatment [Title/Abstract] OR resection surgery [Title/Abstract] OR radical mastectomy for breast cancer [Title/Abstract] OR modified radical mastectomy [Title/Abstract] OR breast-conserving therapy [Title/Abstract]); #3 (preoperative exercise [MeSH Terms]) OR (preoperative care [MeSH Terms]) OR (preoperative exercise [Title/Abstract]) OR (preoperative care [Title/Abstract]) OR (prehabilitation [Title/Abstract]) OR (prerehabilitation [Title/Abstract]) OR (pre-operative rehabilitation [Title/Abstract]) OR (preoperative optimization [Title/Abstract]) OR (surgical preparation [Title/Abstract]) OR (preoperative psychological support [Title/Abstract]) OR (preoperative psychological therapy [Title/Abstract]) OR (preoperative nutrition support [Title/Abstract]) OR (preoperative nutrition therapy [Title/Abstract]); #4 #1 AND #2 AND #3.

2.3 Inclusion and Exclusion Criteria

Inclusion criteria: (1) Female patients diagnosed with breast cancer and undergoing surgical treatment; (2) Patients receiving preoperative prehabilitation intervention, defined as receiving nutritional support, exercise training, or psychological rehabilitation interventions during the period awaiting surgical scheduling; (3) Detailed description of prehabilitation protocol specific contents, including intervention measures, implementation duration, and outcome indicators; (4) Study designs comprising randomized controlled trials, quasi-experimental studies, or observational studies.

Exclusion criteria: (1) Incomplete article content; (2) Full text unavailable.

2.4 Literature Screening and Data Extraction

Retrieved literature was imported into EndNote 21 software for duplicate elimination. Two researchers who had received professional training independently conducted initial screening by reviewing titles and abstracts according to inclusion and exclusion criteria, followed by comprehensive full-text review for secondary screening to determine final included literature. Disagreements arising during literature screening and data extraction processes were resolved through discussion with a third researcher. Researchers independently extracted data, including author, publication year, country, study design, sample size, preoperative prehabilitation intervention protocol, intervention duration, outcome indicators, among other elements.

3. Results

3.1 Literature Screening Results

The systematic search yielded a total of 2,389 relevant articles, comprising 1,765 Chinese-language articles and 624 English-language articles. English literature sources: PubMed database (57 articles), Cochrane Library database (23 articles), Web of Science database (433 articles), Embase database (111 articles). Chinese literature sources: CNKI (478 articles), Wanfang Data Knowledge Service Platform (1,203 articles), VIP Chinese Science and Technology Periodicals Database (74 articles), Chinese Biomedical Literature Database (10 articles). Following duplicate removal, 1,714 articles remained. Initial screening through title and abstract review retained 125 articles. Subsequent full-text secondary screening excluded 107 articles not meeting inclusion criteria, specifically: 14 with mismatched study subjects, 71 with mismatched research content, and 24 with mismatched study designs, ultimately resulting in 16 included articles[10-25]

3.2 General Characteristics of Included Literature

The 16 included articles were published between 2014 and 2025. Geographic distribution: United States (3 articles), Spain (2 articles), Sweden (2 articles), and one article each from Canada, Denmark, Brazil, United Kingdom, Belgium, Chile, Netherlands, Germany, and India. Study designs comprised 12 randomized controlled trials, 1 experimental study, and 3 quasi-experimental studies. The basic characteristics of included literature are presented in Table 1.

Table 1: Basic Characteristics of Included Literature (n=16)

Included Literature	Country	Publication Year	Study Design	Sample Size (Experimental/Control, cases)	Intervention Duration	Intervention Setting	Interventionist	Intervention Protocol
Wright et al.[10]	Canada	2018	RCT	60 cases (30/30)	18 weeks Hospital	Hospital (initial guidance/consultation) + Home (exercise execution) + Telephone (follow-up)	Physical therapist + Nutritionist + Psychiatrist + Smoking cessation team	Multimodal prehabilitation protocol: Exercise prescription (home-based, whole-body + upper limb-specific training); Nutritional counseling; Stress management and smoking cessation intervention (if required) (Frequency: 4 times/week, 60 min/session moderate intensity, 5 min warm-up + 25 min aerobic + 25 min upper limb training + 5 min stretching and relaxation)
Schmitz et al.[11]	United States	2018	RCT	32 cases	2-3 weeks	Rehabilitation hospital (1 week supervised) + Cancer center (education/introduction) + Home (home exercise)	Exercise and oncology specialist + Physical therapist/rehabilitation team + Research personnel	First week: 5 days supervised exercise (3 hours/day) + 2 hours group prehabilitation course; thereafter until surgery: 5 times/week home exercise (resistance + aerobic) + weekly telephone follow-up support; Home prehabilitation group: one-on-one exercise introduction guidance + weekly telephone follow-up support; 5 times/week home exercise (resistance + aerobic) + 2 hours group prehabilitation course
Dalton et al.[12]	Denmark	2020	RCT	120 cases (60/60)	24-30 weeks	Hospital	Physical therapist (exercise supervision) + Research personnel (screening) + Cancer association support center (psychological services)	3 times/week supervised high-intensity interval training (stationary bicycle) + equipment-based resistance combined exercise (large muscle groups) + 4 times psychological distress screening; moderate-to-severe distress referred to cancer association support center
Saraiva et al.[13]	Brazil	2021	RCT	248 cases	16-24 weeks	Hospital + Home	Physical therapist (exercise prescription/telephone follow-up) + Nutritionist (all patients) + Research personnel	Preoperative home-based prehabilitation exercise (3 times/week): Warm-up (upper and lower limbs 1 minute each) + aerobic walking + muscle activation (rectus abdominis contraction, sit-to-stand, upper limb resistance training, 2 sets × 12 repetitions) + stretching and relaxation (20 seconds each) + seated relaxation 5 minutes; accompanied by exercise manual + diary + weekly telephone follow-up; all patients received individualized nutritional guidance from nutritionist
Sebio et al.[14]	Spain	2022	RCT	64 cases (32/32)	8 weeks	Hospital/nearby outdoor	Physical therapist/exercise professional	Nordic walking: Group exercise intervention: 2 times/week, 1 hour 15 minutes each session, for 8 weeks (approximately 16 sessions). Each session comprised: 10 minutes health education + 15 minutes warm-up + 30 minutes Nordic walking + 15 minutes relaxation. Simultaneously
Carmichael et al.[15]	United Kingdom	2023	Quasi-experimental study	34 cases	2 weeks	Home	Physical therapist/exercise professional	Distribution of health education manual, exercise videos, and face-to-face guidance; Preoperative 2 weeks: 2 times/week 60-minute remote supervised exercise + 1 time 30-minute unsupervised walking, including aerobic (jumping jacks, squat jumps, high knees) + resistance band resistance + targeted therapy (breathing training, active assisted/resistance range of motion exercises)
Jo Nijs et al. [16]	Belgium	2023	Quasi-experimental study	50 cases	2 weeks	Home	Not specified	Motivational interviewing throughout the entire intervention process + health education + exercise therapy (150-220 minutes/week moderate-intensity physical activity, home exercise plan (at least 1 time/week: 30-40 minutes moderate-intensity aerobic exercise + 20 minutes strength training + 10 minutes relaxation) + stress management
Busquets et al.[17]	Spain	2024	RCT	76 cases (38/38)	4 weeks	Home	Exercise fitness specialist	Preoperative 4-week prehabilitation exercise plan, 3 times/week; 1 time face-to-face group training + 2 times online video-guided home training. Content included strength training + moderate-intensity aerobic training, circuit format, emphasizing upper
Marzuca-Nassr et al.[18]	Chile	2024	RCT	68 cases (34/34)	16-20 weeks	Hospital	Physical therapist	limb exercise (Frequency: 3 times/week, 1 time face-to-face + 2 times home-based, moderate intensity); Initiating 20 weeks preoperatively, conducting 16-20 weeks whole-body resistance exercise training, 2 times/week. Simultaneously receiving: diagnosis confirmation + chemotherapy plan + initial education course (Frequency: 2 times/week, intensity not specified, intervention content: leg press, leg extension, lat pulldown, chest press, horizontal rowing, grip strength training)
Dijk-Huisman et al.[19]	Netherlands	2024	Quasi-experimental study	11 cases	12-16 weeks	Hospital	Physical therapist, nutritionist	Moderate-intensity endurance training 11 times during chemotherapy infusion, high-intensity interval training and strength training 8 times at 6 weeks preoperatively, nutritional consultation 4 times (45-50 min bicycle + 25 min + 4 strength movements)
Drks et al.[20]	Germany	2020	RCT	64 cases (32/32)	12 weeks	Hospital	Physical therapist	Initiating 12 weeks preoperatively: Resistance-hypertrophy training: Upper limb strength training (biceps brachii, triceps brachii, pectoralis major) + hand-foot vibration training, professional guidance and supervision, 1-2 times/week
Heim	Sw	202	RCT	354 cases	2	Patient	Physical therapist	Preoperative 2 weeks exercise recommendation,

an, J et al.[21]	eden	2		(139/148)	weeks	self-selected (unsupervised)	guidance, patient self-execution	postoperative 4 weeks continued exercise recommendation (Frequency: 30 min daily, moderate intensity)
Heiman,J et al.[22]	Sweden	2021	RCT	400 cases (200/200)	2 weeks	Patient self-selected (unsupervised)	Patient self-execution	Heiman, J et al. [22] Preoperative 2 weeks exercise recommendation, postoperative 4 weeks continued exercise recommendation (Frequency: 30 min daily, moderate intensity)
Knoerl, R et al.[23]	United States	2022	RCT	47 cases (26/21)	4 weeks	Hospital + Home	Physical therapist guidance, patient self-execution	From enrollment to surgery: aerobic exercise and strength training, 2 times/week supervised training + home self-training (Frequency: 2 times/week supervised + home aerobic, 40 min strength + 180 min aerobic, moderate-intensity aerobic)
Ligibel, J.A et al.[24]	United States	2019	RCT	49 cases (27/22)	4 weeks	Hospital + Patient self-selected	Certified exercise trainer + Self-guided	From enrollment to surgery: aerobic exercise and strength training, 2 times/week supervised training + home self-training (Frequency: 2 times/week supervised + home aerobic, 40 min strength + 180 min aerobic, moderate-intensity aerobic)
Lokapavani, Y et al.[25]	India	2014	Experimental study	30 cases (15/15)	1-2 weeks	Hospital Physical therapist	Physical therapist	Preoperative 1-2 weeks physical therapy education and exercise training, postoperative 4 weeks conventional physical therapy (Frequency: 3 times/week)

included Literature	Outcome Indicators
Wright et al.[10]	Feasibility (recruitment rate, adherence, dropout rate, safety, acceptability); Function: grip strength (intervention evaluation: audio usage frequency, satisfaction, CSQ acceptability scale)
Schmitz et al.[11]	Safety, feasibility, acceptability; Quality of life, breast cancer symptoms, fatigue, sleep, depression, shoulder joint problems, physical activity behavior, symptoms
Dalton et al.[12]	Tumor size changes; Body composition, pathological response, chemotherapy completion rate, muscle strength, cardiorespiratory fitness, physical function, tumor biology, liquid biopsy, inflammation/metabolic markers, cell proliferation, physical activity level, quality of life, mental health, clinical outcomes, tumor size, long-term survival
Saraiva et al.[13]	Functional capacity changes (grip strength, 6MWT, 6-minute step test, HRV); Sarcopenia assessment (TUG, SARC-F, corrected arm muscle area); Nutritional risk (PG-SGA), fatigue (FACIT-F), physical activity (IPAQ), quality of life (EORTC QLQ-C30), exercise adherence, behavioral change, patient perception, alcohol and tobacco use (BRFSS), anthropometric data
Sebio et al[14]	Affected upper limb function (Quick DASH); Upper limb volume, range of motion (ROM), pain level, health-related quality of life, grip strength, functional capacity, adherence, physical activity level
Carmichael et al[15]	Recruitment rate, retention rate, adherence, wearable technology use, safety; Behavioral psychology, quality of life, functional disability, fitness test, lymphedema, daily activities, diet, treatment toxicity, chemotherapy completion rate, stereotyped feedback
Jo Nijs et al[16]	Participation rate, patient satisfaction, safety/tolerability, treatment adherence, clinical feasibility; Fatigue, pain, quality of life, physical activity, perceived injustice, self-efficacy, healthcare utilization
Albert Busquets et al[17]	Quality of life (EORTC QLQ-C30, BR23), cancer-related fatigue (FACT-B), body composition (fat mass, lean body mass) (DEXA dual-energy X-ray absorptiometry), bone mineral density (DEXA), cardiorespiratory fitness, grip strength, upper and lower limb maximal strength, shoulder joint range of motion, tumor microenvironment oxyhemoglobin concentration, tumor microenvironment deoxyhemoglobin concentration, tumor microenvironment oxygen saturation, tumor microenvironment blood flow; Height, weight, BMI, waist circumference, hip circumference, bioelectrical impedance analysis, maximal heart rate
Marzuca-Nassr et al[18]	Skeletal muscle mass changes (CT scan: quadriceps cross-sectional area, L3 level muscle area); Muscle strength (upper and lower limb maximal strength), grip strength, physical performance (physical function), functional capacity (walking endurance), quality of life (cancer-related quality of life), cancer-related fatigue, insulin level (metabolic indicator), pathological complete response rate (chemotherapy response), muscle protein expression (molecular mechanism)
Dijk-Huisman et al[19]	Feasibility (recruitment rate, adherence, dropout rate, safety, acceptability); Fatigue (MFI-20), cardiorespiratory fitness (Steep Ramp Test), muscle strength (1RM), nutritional status (PG-SGA)
Drks et al[20]	Postoperative complications; Quality of life (EORTC QLQ-C30, BR23), fatigue (MFI-20), pain, sleep disturbance, anxiety and depression (HADS), menopausal symptoms, lymphedema, shoulder-arm morbidity, grip strength (both hands), hospital stay, chemotherapy-induced peripheral neuropathy (FACT CogNXT), BIA, exercise behavior (BSA)
Heiman, J et al[21]	Quality of life: FACT-B, RAND-36, EQ-VAS, single-item QoL question
Heiman, J et al[22]	Postoperative 4-week physical recovery (self-reported, 0-100% grading); Psychological recovery, hospital stay, reoperation, readmission, complications (CCI score)
Knoerl, R et al[23]	Quality of life (EORTC QLQ-C30), anxiety (HADS), depression (HADS), stress (PSS), cognitive function, insomnia, fatigue, pain, role function
Ligibel, J.A et al[24]	Ki-67 proliferation index changes; Tissue gene expression (RNA-seq), serum metabolic markers (insulin, leptin, adiponectin, IGF-1, CRP, IL-6), tumor immune markers (CD4, CD8, FOXP3, CD56, CD163), apoptosis markers (cleaved caspase-3), insulin receptor
Lokapavani, Y et al[25]	Shoulder joint ROM (flexion, abduction, external rotation, goniometer); Functional activities (SPADI questionnaire)

3.3 Preoperative Prehabilitation Intervention Contents for Breast Cancer Patients

Among the 16 included clinical studies on preoperative prehabilitation for breast cancer patients, intervention measures primarily encompassed multimodal exercise training, individualized nutritional support, and psychological-behavioral interventions. During the period awaiting surgery, breast cancer surgery patients may utilize the preoperative window period of neoadjuvant chemotherapy to undergo prehabilitation intervention. Preoperative multimodal exercise training predominantly comprised aerobic exercise training, resistance training, upper limb/shoulder functional training, breathing training, among others. Prior to exercise initiation, patients' exercise capacity was assessed, with nursing personnel and rehabilitation physicians collaboratively formulating preoperative exercise protocols for patients, with personalized configurations according to each patient's tolerance level. Aerobic training aims to enhance cardiorespiratory endurance, with commonly employed methods including brisk walking, cycling, swimming, treadmill exercise, among others, with exercise intensity adjusted weekly according to the Rating of Perceived Exertion Scale [18]. Beyond aerobic exercise,

appropriate resistance training may be incorporated, primarily targeting core and upper limb major muscle groups, such as chest press, push-ups, barbell curls, sit-ups, squats, shoulder abduction, resistance band pulls, among others, with training frequency of 3-4 times/week, completing 1-3 sets of each movement, with 8-12 repetitions per set [12,13]. Certain studies [15] introduced wearable devices to monitor parameters including step count and heart rate. Training intensity was moderate, exercise duration was 30-60 minutes/session, and frequency was 3-5 times/week. To enhance patient adherence, some studies [10, 16] employed motivational strategies, sustained until intervention completion.

Regarding nutritional intervention, three studies [10, 13, 19] adopted combined exercise and nutrition approaches. Nutritionists provided individualized consultation for operable breast cancer patients during the preoperative window period, with core objectives of optimizing preoperative physiological reserve and enhancing treatment tolerance through nutritional status improvement, and encouraging patients to actively participate in self-monitoring.

Regarding psychological intervention, Dalton et al. 3. [12] employed a paradoxical design of "detecting distress but not managing distress"—it identified moderate-to-severe psychological distress through the most refined screening system, yet delivered intervention to a completely uncontrolled external black box, rendering its psychological dimension's scientific value limited to "descriptive monitoring" rather than "causal verification." In contrast, Wright et al. [10] represented the "heavy model" extreme of psychological intervention in breast cancer prehabilitation — with built-in psychiatrists, CBT technique packages, universal preventive intervention, and strict adherence monitoring — forming a sharp contrast with Dalton et al. [12]'s "light-touch screening," together constituting the methodological spectrum of this field from "not managing" to "fully managing." Nevertheless, current coverage of nutritional and psychological intervention in preoperative prehabilitation for breast cancer patients remains insufficient, with intervention content still dominated by exercise, and ERAS-based prehabilitation protocols urgently requiring standardization.

3.4 Key Points of Preoperative Prehabilitation Intervention for Breast Cancer Patients

Key points of preoperative prehabilitation intervention for breast cancer patients primarily include intervention intensity, intervention duration, intervention implementers, and implementation settings. Twelve studies [10, 12-17, 19, 21-24] described exercise intervention intensity and frequency in detail, nine studies [10-15, 19, 24, 25] briefly explained exercise intervention content, and one study [10] only reported patients' preoperative psychological status and nutritional assessment indicators, clearly specifying psychological intervention frequency but not specific nutritional prescription intensity or supplementation dosage. Regarding exercise intervention, certain studies [15] integrated wearable devices to monitor exercise-related data. Prehabilitation methods selected included hospital-based guided training and home self-exercise, with intervention duration ranging from 1-2 weeks to 24-30 weeks preoperatively. Intervention methods primarily comprised exercise training, nutritional support, or psychological support. Prehabilitation team composition included physical trainers, nutritionists, psychotherapists, clinicians, and nurses, among others. For home-based studies, weekly telephone follow-up or online video guidance was typically employed to enhance patient adherence; however, home data collection carried selection bias risks [10, 11, 13, 15-17, 19, 22, 24, 25]. Currently, preoperative prehabilitation for breast cancer patients exhibits differences in intervention intensity, duration, and implementation models, still requiring more evidence-based research for verification and optimization.

3.5 Evaluation Indicators of Preoperative Prehabilitation for Breast Cancer Patients

The 16 included articles involved evaluation indicators across seven domains: (1) Feasibility indicators including recruitment rate [10, 19], adherence/completion rate [10, 19], dropout rate/retention rate [10, 15, 19], safety/tolerability [10, 19], patient satisfaction/acceptability [10, 16, 19], wearable technology use [15]. (2) Physical function and fitness indicators including grip strength [10, 13, 17, 18, 20], 6MWT and 6-minute step test [10, 13], cardiorespiratory fitness [12, 17, 19], muscle strength/maximal upper and lower limb strength [12, 17, 19], walking endurance/functional capacity [14, 18] fitness test [15], range of motion (ROM) [14, 17, 25], affected upper limb function (Quick DASH) [14], functional activities (SPADI questionnaire) [25], body composition (fat mass, lean body mass, bone mineral density) [12, 17], skeletal muscle mass (CT) [18] sarcopenia assessment (TUG [Timed Up and Go test], SARC-F) [13], BIA bioelectrical impedance analysis [17, 20], anthropometric data (BMI, waist circumference, hip circumference) [13, 17]. (3) Quality of life and symptom burden indicators including quality of life (EORTC QLQ-C30, EORTC QLQ-BR23, FACT-B, RAND-36, EQ-VAS) [13, 17, 18, 20-23], cancer-related fatigue (FACT-B, FACIT-F, MFI-20) [11, 13, 16, 17, 19, 20, 23], pain [14, 16, 20, 23], sleep disturbance [11, 20], menopausal symptoms [20], chemotherapy-induced peripheral neuropathy [20], treatment toxicity [15]. (4) Breast cancer-specific outcome indicators including tumor size changes [12], pathological response/pathological complete response rate (pCR) [12, 18] chemotherapy completion rate [12, 15], long-term survival [12] upper limb volume/lymphedema [14, 15, 20], shoulder-arm morbidity [20], shoulder joint problems [11]. (5) Tumor biology/molecular mechanism indicators including tumor biology/liquid biopsy [12] cell proliferation/Ki-67[12, 24], tumor microenvironment (oxyhemoglobin, deoxyhemoglobin, oxygen saturation, blood flow) [17], tissue gene expression (RNA-seq) [24], apoptosis markers (cleaved caspase-3) [24], insulin receptor [24], muscle protein expression (molecular mechanism) [18], metabolic/inflammatory markers [12] serum metabolic markers (insulin, leptin, adiponectin, IGF-1, CRP, IL-6) [24] tumor immune markers (CD4, CD8, FOXP3, CD56, CD163) [24] (6) Psychosocial and behavioral indicators including anxiety/depression (HADS) [20, 23], stress (PSS) [23], depression[11], cognitive function [20, 23], self-efficacy [16], perceived injustice [16], role function [23], behavioral psychology [15], Health Action Process Approach (HAPA) [15], Dyadic Coping [15], patient perception [13],

patient-centered approach [16], physical activity level/behavior [12-14, 16, 20] exercise behavior (BSA) [20], IPAQ physical activity questionnaire [13] diet/daily activities [15], alcohol and tobacco use (BRFSS) [13], stereotyped feedback [15].(7) Postoperative clinical outcomes including postoperative complications [20-22], hospital stay/days [20-22], readmission/reoperation [21, 22], complications (CCI) [21, 22], postoperative 4-week physical recovery/ psychological recovery [21, 22].

4. Discussion

4.1 Breast Cancer Prehabilitation Transitioning from Single-Modal to Multimodal Approaches, with Multimodal Prehabilitation Still in Its Nascent Stage

This study systematically analyzed the application value of prehabilitation intervention in preoperative management of breast cancer patients. Compared with conventional surgical procedures, the intervention period of preoperative prehabilitation for breast cancer patients is generally longer. Studies [10, 12, 13, 18-20] demonstrate that most breast cancer patients undergo neoadjuvant chemotherapy preoperatively, with prehabilitation protocol intervention duration of 12-30 weeks, providing sufficient window period for systematically enhancing patients' physical fitness and overall status. With the widespread application of exercise prehabilitation in breast cancer patients, research has gradually evolved from single-modal to multimodal approaches, with related intervention content progressively encompassing nutrition and psychological domains.

In terms of nutritional prehabilitation, Wright et al. [10] followed the "screening - assessment - diagnosis - intervention - monitoring" process for nutritional intervention in cancer patients; however, this study primarily targeted feasibility as its objective, not reporting independent effectiveness data of nutritional intervention, reflecting the methodological dilemma wherein nutritional intervention in multimodal prehabilitation research is frequently "submerged" within overall effect evaluation. Saraiva et al. [13]'s nutritional intervention exhibited distinct resource-limited environment adaptability characteristics, with its large sample size of 248 cases and 2×2 factorial design providing potential possibility for exploring nutrition-exercise interaction effects. Moreover, this study employed anthropometric indicators such as body weight and triceps skinfold thickness, rather than CT muscle area or BIA phase angle commonly utilized in modern nutritional assessment, which to some extent limited nutritional outcome precision. Dijk et al. [19]'s nutritional design introduced digital health tools, with 4 nutritionist consultations, free digital food diary, and quantified goals, responding to the "precision nutrition" trend in oncology nutrition, attempting to enhance adherence and effectiveness through real-time feedback; however, this study commenced recruitment in 2024, and results remain unavailable.

In terms of psychological intervention, only three studies [10, 15, 16] incorporated psychological intervention as active treatment design, two [12, 24] adopted screening-referral or self-guided models; the remaining studies either contained only educational elements or completely did not involve psychological dimensions. This distribution reveals the structural imbalance of "emphasizing physical, neglecting psychological" in the field of breast cancer prehabilitation. Currently, multimodal prehabilitation research in the breast cancer domain remains in its nascent stage, with related evidence still insufficient. Future large-sample, multicenter clinical trials are required to deeply explore the effectiveness and feasibility of multimodal prehabilitation.

4.2 Preoperative Prehabilitation Protocols for Breast Cancer Patients Urgently Requiring Optimization, with Precision Intervention Through Window Periods

During prehabilitation implementation, exercise prehabilitation-related research continues to increase; however, preoperative exercise prehabilitation protocols still exhibit considerable variation in initiation timing, intervention intensity, intervention duration, implementation location, and intervention implementers. Regarding intervention initiation timing and indications, the majority of studies [10, 12, 13, 18, 19] advocate early initiation of prehabilitation intervention when breast cancer patients enter the preoperative neoadjuvant chemotherapy period. Nevertheless, specific initiation timing still requires comprehensive consideration of multiple factors.

Regarding intervention intensity, the current trend is shifting from low-to-moderate intensity training toward moderate-to-high intensity. Certain studies [17, 25] adopted low-to-moderate intensity training protocols, but with weaker effects on enhancing cardiorespiratory fitness and muscle strength. In contrast, Dijk et al. [19]'s moderate-to-high intensity aerobic exercise + strength training comprehensively optimizes preoperative status and alleviates preoperative anxiety and stress. Therefore, current research increasingly tends toward moderate-to-high intensity training models, providing optimal physiological foundation for surgery and subsequent treatment. The key to physical fitness improvement lies in whether intervention intensity meets standards and whether supervision is present. Consequently, how to balance optimal intervention duration with actual patient adherence and training intensity becomes an important focus for subsequent research.

Regarding intervention location, hospital-based supervised training facilitates ensuring patient safety and movement standardization; however, patient feasibility of traveling to participate in training is constrained. In contrast, home-based or remote intervention enhances accessibility and convenience. With the popularization of wearable devices and mobile internet, remote prehabilitation has emerged as a development focus. Certain studies [10, 12, 14] employed highly supervised, hospital or community center-based intensive training; other studies [15, 16] relied on telecommunication technology-enabled remote models. The advantage of supervised intervention lies in quality assurance and control. Knoerl et al. [23]'s secondary analysis of Ligibel et al. [24]'s study revealed an important finding: exercise and mind-body interventions demonstrated equivalent effectiveness in improving anxiety and stress; however, the mind-body group exhibited superior performance in cognitive function and insomnia. This suggests that the "active ingredients" of prehabilitation may vary according to outcome objectives, and single exercise modality may not represent the

optimal solution.

The emergence of remote prehabilitation reflects implementation science requirements in the post-pandemic era. Nijs et al. [16] adopted a pure remote model, combining motivational interviewing and shared decision-making; Carmichael et al. [15]'s study integrated the NHS Attend Anywhere platform, wearable devices, and HAPA behavior change theory. The feasibility of these designs awaits verification; however, Saraiva et al. [13]'s large-sample RCT with 248 cases, through weekly telephone follow-up + home exercise manual model, provided possibility for scaling in resource-limited environments. Nevertheless, Heiman et al. [22]'s experience cautions that low-intensity, unsupervised interventions may confront the dilemma of "recommended but not executed," with exercise diary demonstrating adherence below 60%, and SGPALS assessment showing no difference in activity level changes between intervention and control groups. Therefore, future preoperative prehabilitation for breast cancer patients should further strengthen multidisciplinary collaboration and intelligent management, continuously exploring home-based, remote, and digital management models, fully leveraging synergistic effects between hospitals and intelligent devices to enhance preoperative physical reserve and surgical tolerance of breast cancer patients, thereby optimizing prognosis and postoperative quality of life.

4.3 Recommendations for Future Prehabilitation in Clinical Management of Breast Cancer Patients

Prehabilitation has demonstrated significant effects in improving physical and mental status, enhancing postoperative quality of life, and optimizing clinical outcomes for breast cancer patients. Nevertheless, several aspects still await exploration and refinement.

First, patient adherence monitoring should be strengthened to enhance prehabilitation protocol implementation effectiveness. Existing studies indicate that hospital-based face-to-face prehabilitation programs demonstrate higher adherence; however, as intervention duration extends, patient adherence progressively declines due to factors including neoadjuvant chemotherapy, fear of tumor recurrence, and financial pressure. Moreover, simple telephone follow-up demonstrates limited efficiency. Therefore, it is recommended to comprehensively consider personalized factors including patient preferences, economic status, education level, and social support during protocol design, while abandoning simple "recommendation-style" intervention in favor of structured models encompassing at least 2 times/week face-to-face or remote supervision, and integrating health education throughout the entire prehabilitation process, covering preoperative surgery-specific education, postoperative early activity guidance, and importance of maintaining exercise during neoadjuvant chemotherapy, among other content.

Second, future integration of artificial intelligence monitoring and wearable devices and other intelligent equipment may enable real-time tracking and dynamic adjustment, such as utilizing smart bracelets to track step count, heart rate, and activity intensity for objective quantification of adherence, employing virtual reality exposure or distraction interventions to alleviate preoperative anxiety, utilizing AI assistance to generate individualized exercise prescriptions based on baseline cardiorespiratory function, muscle strength, and nutritional status, and continuously promoting "Internet + Nursing" platform construction to enhance convenience and efficiency, thereby transcending geographical, temporal, and human resource limitations. Third, prehabilitation time windows require extension, with resource allocation and follow-up strategies optimized. Breast cancer prehabilitation is characterized by special time windows, brief preoperative windows, rapid postoperative adjuvant chemotherapy initiation, and extended long-term survival periods. It is recommended to establish a whole-process management pathway from diagnosis confirmation triggering synchronous assessment, through preoperative intensive prehabilitation, perioperative ERAS protocol integration, adjuvant therapy period exercise during chemotherapy infusion, and survivor period long-term follow-up, with multi-timepoint follow-ups at postoperative 4 weeks, 3 months, 12 months, and 2-5 years to comprehensively assess functional recovery, quality of life trajectories, and chronic complications.

Fourth, special populations require attention with precise strategies formulated. For neoadjuvant chemotherapy patients, adopt exercise during chemotherapy infusion combined with HIIT during intervals; for immediate breast reconstruction patients, strengthen preoperative core stability training and long-term follow-up; for elderly patients, commence with low intensity and emphasize strength and balance training; for axillary lymph node dissection patients, preoperatively establish shoulder ROM baseline and conduct lymphedema lifelong prevention education; for adjuvant chemotherapy subgroups, strengthen psychological support and fatigue management special intervention; for HER2+ patients, emphasize cardioprotective effects of aerobic exercise.

Finally, future research directions should prioritize pragmatic RCTs or cohort studies including cost-effectiveness comparison of supervised versus unsupervised prehabilitation, impact of prehabilitation on chemotherapy completion rate and dose intensity, immune mechanism-driven precision prehabilitation molecular subtype screening, while exploring non-inferiority of remote digital prehabilitation, optimal prehabilitation initiation timing, and patient preferences and shared decision-making, and conducting long-term follow-up assessment of prehabilitation impact on recurrence and survival.

5. Conclusion

This study conducted a scoping review of preoperative prehabilitation application in breast cancer patients, systematically reviewing current research progress in intervention measures, intervention intensity, intervention duration, and evaluation indicators. Principal limitations of current research include relatively single prehabilitation modalities, predominantly exercise intervention-dominated, with relatively insufficient attention to nutrition and psychological intervention; future efforts still require further expansion toward multimodal comprehensive intervention directions. Furthermore, formulation of intervention duration and intensity has not yet achieved clear consensus, urgently

requiring verification and standardization through additional high-quality randomized controlled trials. Concurrently, prehabilitation initiation timing should comprehensively consider multiple factors to achieve precision and individualization of preoperative intervention.

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