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Dolna 17, Warsaw,
Poland 00-773
+48 226 0 227 03
editorial_office@rsglobal.pl

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INTEGRATING PHYSICAL ACTIVITY INTO THE RECOVERY PATHWAY AFTER BREAST CANCER – A NARRATIVE REVIEW

Maciej Borowski *(Corresponding Author, Email: maciej.piotr.borowski@gmail.com)*
Central Clinical Hospital of the Medical University of Łódź, Łódź, Poland
ORCID ID: 0009-0001-0789-804X

Natalia Śliwa
Maria Skłodowska-Curie Provincial Specialist Hospital in Zgierz, Zgierz, Poland
ORCID ID: 0009-0000-9829-1915

Eliza Kawalska
Hospital of Our Lady of Perpetual Help in Wołomin, Wołomin, Poland
ORCID ID: 0009-0004-8244-6459

Kacper Zielonka
Maria Skłodowska-Curie Provincial Specialist Hospital in Zgierz, Zgierz, Poland
ORCID ID: 0009-0009-5149-7786

Bartosz Dądela
Maria Skłodowska-Curie Provincial Specialist Hospital in Zgierz, Zgierz, Poland
ORCID ID: 0009-0003-2408-9812

Sara Langner
Central Clinical Hospital of the Medical University of Łódź, Łódź, Poland
ORCID ID: 0009-0009-4306-4024

Szymon Janczura
Central Clinical Hospital of the Medical University of Łódź, Łódź, Poland
ORCID ID: 0009-0009-4214-4014

Szymon Gnitecki
Provincial Multi-Specialist Center of Oncology and Traumatology M. Copernicus in Łódź, Łódź, Poland
ORCID ID: 0009-0007-6839-6207

Marcin Markowski
Medical University of Łódź, Łódź, Poland
ORCID ID: 0009-0006-5497-1138

Joanna Jasińska
Central Clinical Hospital of the Medical University of Łódź, Łódź, Poland
ORCID ID: 0009-0008-2496-1355

ABSTRACT

Breast cancer remains the most frequently diagnosed malignancy among women worldwide. Although surgical approaches, being the first-line treatment in most cases of breast cancer, such as mastectomy and breast-conserving therapy (BCT), often combined with sentinel lymph node biopsy (SLNB) or axillary lymph node dissection (ALND), are critical for disease management, they are often accompanied by a range of physical, psychological, and functional challenges that persist well beyond the perioperative period. Throughout recent years, structured physical activity has gained recognition as a non-pharmacological intervention aimed in reducing adverse effects adverse effects of surgical intervention in breast cancer. This narrative review summarizes findings from studies published between 2002 and 2025 about the role of physical activity in breast cancer treatment, focusing specifically on the postoperative period. The findings show a range of physical activities and how some of them can support recovery after surgery. They can improve lymphatic and musculoskeletal function. They also help reduce cancer-related fatigue, pain, and emotional distress. Of note, the extent of benefit varies depending on the type of surgical procedure. For example mastectomy patients generally requiring more extensive rehabilitation than those after regular BCT. Despite all these differences, individualized exercise programs have been associated with significant improvements across diverse clinical contexts. Given its proven efficacy and safety, physical activity should be regarded as a intrinsic element of integrative breast cancer care, included in both perioperative protocols and long-term survivorship plans. Future studies should focus on developing precision-based exercise models. They should also explore the biological mechanisms that connect specific movements to recovery and resilience.

KEYWORDS

Breast Cancer, Physical Activity, Surgical Rehabilitation, Mastectomy, Breast-Conserving Therapy, Lymphedema, Survivorship, Exercise Oncology

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1. Introduction

Breast cancer is the most commonly diagnosed cancer in women. In 2022, there were around 2.3 million new cases and nearly 666,000 deaths worldwide, according to the GLOBOCAN 2022 estimates (Filho et al., 2025). Thanks to earlier detection and more effective treatments, survival rates have substantially improved. Consequently, people are becoming more aware of the long-term physical and psychological effects of breast cancer treatment (Janz et al., 2005; Silver et al., 2013). Among the major treatment options, surgery, which includes breast-conserving therapy (BCT) with radiotherapy or total mastectomy, is crucial for controlling early-stage breast cancer. Long-term randomized trials indicate that survival outcomes are similar for both techniques. This supports using BCT for eligible patients (Veronesi et al., 2002).

The physical effects of breast cancer surgery are often neglected. Beyond the immediate changes from tissue removal, axillary procedures, and reconstructive surgeries, many patients deal with ongoing issues such as reduced shoulder movement, lymphedema, poor posture, nerve pain, and cancer-related fatigue (Shamley et al., 2012; Schmitz et al., 2010a; McNeely et al., 2010). These problems extend beyond physical challenges; they can also impact emotional well-being, work life, body image, and overall quality of life (Janz et al., 2005; Silver et al., 2013; Rietman et al., 2006). Importantly, even in the absence of clear lymphedema, subtle issues in the upper arm and hand—like limited movement, weaker muscles, and sensory problems—can disrupt daily activities and might persist for months or years after treatment. These outcomes emphasize the need for early and widespread rehabilitation efforts. Thus, there is increasing attention on safe, non-drug methods, particularly structured physical activity, as an established way to address the complex challenges of breast cancer survivorship (Schmitz et al., 2010a; Courneya et al., 2007).

In recent years, exercise oncology has gained more importance. It showcases the healing benefits of regular physical activity for prevention, treatment, recovery, and survivorship (Schmitz et al., 2010a). Lymphedema is one of the toughest side effects of breast cancer treatment, impacting up to 30% of patients after axillary surgery. Physical activity, previously thought to be harmful, is now recognized as a safe and effective means to manage lymphedema. It can boost lymphatic flow and reduce limb volume without worsening symptoms (Johansson et al., 2005; DiSipio et al., 2013; Campbell et al., 2019).

Structured exercise has also been shown to enhance cardiovascular function, maintain lean body mass, decrease inflammation, and potentially influence tumor biology through immune and hormone pathways (Campbell et al., 2019; Jones & Alfano, 2013; Dieli-Conwright & Orozco, 2015; He et al., 2024). These findings support the inclusion of personalized exercise programs as a regular part of survivorship care for breast cancer patients at risk for or affected by lymphedema.

Despite growing evidence supporting the role of physical activity in breast cancer care, limited research exists on how exercise interventions differ based on surgical methods like mastectomy, breast-conserving therapy (BCT), or reconstructive procedures. Many studies affirm the benefits of physical activity during cancer treatment. However, few have closely examined how the type and timing of exercise interact with specific surgical approaches (Kim et al., 2019; Vohra et al., 2023; McNeely et al., 2006). This review aims to consolidate current scientific knowledge on how structured physical activity relates to surgical treatment options in breast cancer. It will focus on physiological mechanisms, clinical outcomes, and future directions for personalized rehabilitation strategies (Silver et al., 2013; Schmitz et al., 2019).

2. Surgical Modalities in Breast cancer

Surgical treatment of breast cancer is essential for controlling local disease. It involves the complete removal of the primary tumor and allows for accurate pathological staging (Veronesi et al., 2002). The choice of primary surgical options depends on tumor biology, how far the disease has progressed, and patient preferences. These options include breast-conserving therapy (BCT), total mastectomy, and mastectomy with immediate or delayed reconstruction (Dauplat et al., 2017; Pačarić et al., 2022; He et al., 2024).

BCT usually requires follow-up radiotherapy. It tends to have a shorter recovery time and better body image outcomes. In contrast, mastectomy might be necessary for multifocal tumors, patients with BRCA mutations, or when radiotherapy is not an option (Witmanowski & Budner, 2024; National Cancer Institute, 2024). Each surgical approach brings different physical and mechanical challenges, affecting postoperative issues, the likelihood of complications like lymphedema, and when physical rehabilitation can begin (Shamley et al., 2012; Carr et al., 2024). Understanding these differences is important for designing exercise-based interventions, as these must align with recovery progress and expected functional limitations (Silver et al., 2013).

2.1 Breast-Conserving Therapy (BCT)

Breast-conserving therapy (BCT) involves removing the tumor along with a margin of healthy tissue. This is usually followed by radiation therapy. BCT has become a standard treatment for early-stage breast cancer because it provides the same cancer control as mastectomy while offering better cosmetic results. It helps maintain breast integrity and boosts patient body image (Veronesi et al., 2002). Several studies show that BCT leads to shorter hospital stays, fewer complications during surgery, and improved quality of life compared to total mastectomy (Dauplat et al., 2017; Vohra et al., 2023; He et al., 2024).

However, BCT does have its drawbacks. Side effects from radiation therapy, such as skin hardening, small blood vessel changes, and localized pain, can affect soft tissue flexibility and arm movement (Bourgeois et al., 2003; Williams et al., 2019; Harris, 2024). Additionally, although rare, radiation can cause brachial plexopathy, leading to nerve pain, numbness, and long-term movement issues. This makes rehabilitation much more complicated (Harris, 2024). Furthermore, capsular contracture after radiation in reconstructed patients can restrict shoulder movement and hinder physical therapy (Nava et al., 2019).

2.2 Total Mastectomy

Mastectomy, which is the complete removal of breast tissue, remains the preferred surgical choice for multicentric tumors, patients who cannot have radiotherapy, those with BRCA1/2 mutations, and when patients prefer this option. Techniques range from simple mastectomies to skin-sparing and nipple-sparing mastectomies. Each method offers different levels of aesthetic and functional preservation (Witmanowski & Budner, 2024; National Cancer Institute, 2024).

Compared to breast-conserving therapy (BCT), mastectomy generally involves a longer recovery period, more significant shoulder issues, thoracic adhesions, phantom breast syndrome, and psychological effects, such as body image concerns and post-traumatic stress (Janz et al., 2005; Vilholm et al., 2008; Wu et al., 2016). It is also important to note that axillary lymph node dissection (ALND) is often done at the same time as mastectomy. This procedure greatly raises the risk of lymphedema, which is one of the most common long-term complications. It affects up to 30% of patients, depending on the assessment method and how long they are followed (McLaughlin et al., 2008; DiSipio et al., 2013).

The greater level of surgical trauma in mastectomy patients leads to more serious upper limb function problems. This highlights the urgent need for early physical rehabilitation. Well-structured physical activity and specific physiotherapy programs are key to improving shoulder motion, reducing pain, and avoiding harmful compensatory movement patterns (Lauridsen et al., 2005).

2.3 Mastectomy with Immediate or Delayed Reconstruction

Breast reconstruction can be done with either implant-based or autologous tissue methods, and can happen at the same time as the primary surgery or later. While reconstruction can improve psychological well-being and body image, it also comes with longer surgery times, more days in the hospital, and higher complication rates, especially when it is done alongside radiotherapy (Pačarić et al., 2022; Jagsi et al., 2016; Nava et al., 2019; Guliyeva et al., 2022).

Autologous techniques, especially the deep inferior epigastric perforator (DIEP) flap, provide more natural-looking results but require complex microsurgery and a longer recovery period (Garvey et al., 2006; Guinier et al., 2023). Patients who have these procedures often face reduced mobility not just in the chest area but also at the donor site. This limitation demands focused rehabilitation to improve flexibility, core strength, and muscle balance (Dieli-Conwright & Orozco, 2015; Sander et al., 2012; Carr et al., 2024).

Studies show that while long-term satisfaction with reconstruction may increase, the early recovery phase often experiences greater functional limitations compared to mastectomy alone, unless early rehabilitation is started (Nesvold et al., 2008; Shamley et al., 2012; Kim et al., 2019). Therefore, rehabilitation specialists need to customize exercise plans based on the type of reconstruction, surgical scarring, implant placement, and the chance of delayed wound healing.

3. Physiological and Functional Consequences of Surgery

Surgical treatment for breast cancer is effective in controlling local tumors, but it often leads to various physical and functional issues. These can include problems with upper limb movement, balance, lung expansion, and overall physical ability. If these complications are not addressed quickly and systematically, they can hinder recovery, daily activities, and overall quality of life (Shamley et al., 2012; Silver et al., 2013; Dieli-Conwright & Orozco, 2015). Therefore, combining specific physical rehabilitation strategies with regular cancer care is crucial to reduce these effects and promote long-term survival.

3.1 Musculoskeletal Impairments

Post-surgical problems in musculoskeletal function are some of the most common complications after breast surgery. These problems include limited shoulder range of motion (ROM), scapular dyskinesis, rotator cuff dysfunction, and stiffness in the thoracic spine (Rietman et al., 2006). Disruption of pectoral and axillary structures during surgery, along with protective postures and lack of use, leads to soft tissue adhesions and muscle imbalances (Shamley et al., 2012).

Scapular misalignment and changes in neuromuscular coordination are often seen, especially after mastectomy and axillary lymph node dissection (ALND). These issues can last long after the wounds have healed, potentially causing chronic compensatory patterns unless addressed by early physical therapy (Harrington et al., 2013; Carr et al., 2024). Additionally, pain from incisions and axillary cord syndrome (also called cording) make movement limitations and fear of movement worse (Koehler et al., 2018).

3.2 Lymphedema and Vascular Complications

Lymphedema is one of the most challenging effects of breast cancer surgery, especially for patients who have axillary lymph node dissection (ALND) or regional radiotherapy. It occurs because of the disruption in lymphatic drainage pathways and can appear months or even years after treatment (DiSipio et al., 2013). Clinically, lymphedema shows up as chronic swelling, a feeling of heaviness, tight skin, and a higher risk of infections like cellulitis in the affected arm.

Estimates indicate that 20 to 30% of patients develop lymphedema after axillary clearance. Its prevalence is affected by the duration of follow-up, body mass index, and additional therapies (McLaughlin et al., 2008). This condition greatly reduces physical ability and often needs ongoing management, which may include compression garments, manual lymphatic drainage, and customized exercise programs (Fu et al., 2015).

Importantly, new evidence shows that supervised physical activity does not worsen lymphedema and may even improve lymphatic flow and manage symptoms (Brown et al., 2012; Cormie et al., 2013). Resistance and aerobic training, when tailored correctly, are increasingly recommended as safe and useful parts of lymphedema management plans (Campbell et al., 2019; Hasenoehrl et al., 2020). Recent meta-analyses support that structured exercise leads to better outcomes in limb volume, strength, and quality of life without raising risk (Singh et al., 2016; Schmitz et al., 2019).

These findings are now included in international guidelines that encourage adding physical activity to routine survivorship care. This highlights its role not only in managing lymphedema but also in enhancing overall recovery and cancer outcomes (Schmitz et al., 2019; Hayes et al., 2009).

3.3 Pain Syndromes and Sensory Changes

Post-mastectomy pain syndrome (PMPS) affects up to 50% of patients. It may show up as neuropathic pain, numbness, tingling, or burning sensations in the chest wall, armpit, or upper arm (Vilholm et al., 2008). The causes of PMPS are complex. They include nerve injury, most often to the intercostobrachial nerve, tension from scar tissue, and psychological factors such as anxiety, depression, and avoidance behaviors (Andersen & Kehlet, 2011; Stubblefield & Keole, 2014).

Poor pain management during the early recovery period may restrict movement. This can lead to compensatory movement patterns and a higher risk of long-term disability. Additionally, many patients report sensory problems after mastectomy and reconstructive surgeries. These issues, such as reduced sensation and abnormal sensations, often disrupt body awareness and coordination in the arm (Nesvold et al., 2008).

New research indicates that implant-based reconstruction might lead to higher rates of ongoing pain. This could be due to the body reacting to the implants, the formation of scar tissue, and irritation of nearby nerves (Guliyeva et al., 2022). Rehabilitation efforts should not only aim to restore motor function but also include methods for desensitization, nerve mobilization, and personalized pain education. Early intervention by a team that includes physiotherapy, psychoeducation, and occupational therapy is vital to reducing long-term issues.

3.4 Psychophysiological and Systemic Effects

Beyond local impairments, surgical treatment for breast cancer affects the body's overall systems and mental health. Breast cancer survivors often deal with chronic fatigue, insomnia, lower fitness levels, and muscle weakness (Courneya et al., 2007; Mustian et al., 2017; Alfano et al., 2009). These issues are partly caused by higher levels of inflammatory substances, like IL-6 and TNF-α, which lead to fatigue and muscle loss (Kim et al., 2020; Rock et al., 2022).

On a psychological level, a cancer diagnosis and treatment—along with surgical changes and issues with body image—can lead to anxiety, depression, low self-confidence, and avoidance behaviors. These factors can hinder participation in rehabilitation programs (Janz et al., 2005; Silver et al., 2013). A biopsychosocial rehabilitation approach is vital to regain independence. Exercise can help improve mood and counteract physical decline by influencing neuroendocrine function (Schmitz et al., 2019; Ridner, 2009).

Therefore, support from various professionals and tailored activity plans are essential for enhancing both physical and emotional recovery in breast cancer survivors.

4. The Role of Physical Activity in Recovery and Survivorship

Physical activity (PA) is increasingly seen as a key part of recovery and long-term care for breast cancer patients. The American College of Sports Medicine (ACSM) and several international oncology groups now support structured exercise as an important therapy to reduce treatment side effects, improve function, and enhance quality of life (Campbell et al., 2019; Schmitz et al., 2010a; Hayes et al., 2009; Schmitz et al., 2019).

These guidelines also stress that exercise programs should be personalized based on each patient's situation, which includes their health conditions, treatment stage, and surgical history (He et al., 2024; Veronesi et al., 2002). Research shows that patients who undergo breast-conserving surgery often keep more physical

function after surgery than those who have a mastectomy. This difference can affect their rehabilitation paths and how well they tolerate exercise (Shamley et al., 2012; Janz et al., 2005).

New evidence also supports exercise for tackling cancer-related fatigue, boosting mental health, and preventing long-term disability. This makes PA a fundamental part of survivorship planning (Mustian et al., 2017; Silver et al., 2013; Rock et al., 2022). Therefore, physical activity is not just an addition but a crucial, evidence-backed treatment in overall breast cancer care.

4.1 Exercise Modalities and Their Mechanisms

Physical rehabilitation for breast cancer survivors must address physical deconditioning and post-surgical limitations as well as the systemic effects of chemotherapy, endocrine therapy, and radiotherapy. Different forms of exercise offer unique physiological benefits, which, especially when combined, improve recovery, functionality, and long-term survivorship.

Aerobic Training

Aerobic activities such as brisk walking, cycling, and swimming significantly improve cardiorespiratory fitness (VO_2 max), reduce cancer-related fatigue (CRF), and improve lymphatic return. This is crucial for patients with or at risk of upper-limb lymphedema after axillary surgery (Courneya et al., 2007; Schmitz et al., 2010a; Schmitz et al., 2010b; Singh et al., 2016; Kim et al., 2009). Meta-analyses consistently show that 90–150 minutes per week of moderate-intensity aerobic exercise reduces CRF and may decrease systemic inflammation by lowering IL-6 and TNF-α levels (Schmitz et al., 2010b; Singh et al., 2016; Kim et al., 2009; McNeely et al., 2006; Kim et al., 2020).

Resistance Training

Resistance training using weights or elastic bands helps maintain or increase lean body mass, muscle strength, and bone mineral density, which counteracts sarcopenia and osteopenia, common side effects of endocrine therapy such as aromatase inhibitors and corticosteroid use (Winters-Stone et al., 2012; Cheema et al., 2014). Structured resistance programs conducted 2–3 times a week have shown to be safe and effective, even for women with existing lymphedema. These programs consistently lead to improvements in upper and lower body strength without negatively affecting limb volume or exacerbating lymphedema (Hasenoehrl et al., 2020; Cormie et al., 2013). Additionally, resistance exercise may positively impact metabolic biomarkers like insulin and IGF-1, which can further enhance survivorship outcomes (Schmitz et al., 2005). A recent meta-analysis reported a 47% reduction in the risk of worsening lymphedema (OR 0.53), along with significant increases in strength (SMD ≈0.57 upper body, 0.48 lower body) (Hasenoehrl et al., 2020).

Flexibility and Mobility Exercises

Post-surgical shoulder stiffness and capsular tightness can be alleviated with mobility exercises such as pendulum swings, wall climbs, and shoulder elevations. These help restore range of motion, correct posture, and decrease myofascial pain (Kim et al., 2019; McNeely et al., 2006). When combined with resistance training, these programs lead to better functional recovery in older breast cancer survivors (Winters-Stone et al., 2012).

Mind-Body Practices (Yoga, Tai Chi, Pilates)

Mind-body interventions promote relaxation, lower cortisol levels, and support emotional health, body image, and sleep quality (Buffart et al., 2012; Cramer et al., 2012). While there are fewer randomized controlled trials (RCTs) compared to conventional exercise, systematic reviews confirm that 6–12 week yoga programs reduce fatigue, anxiety, and pain while improving quality of life with minimal physical stress. These benefits are notably important for patients unable to participate in higher-intensity activities. Furthermore, mind-body practices help in achieving autonomic balance and enhance readiness for broader rehabilitation strategies (Schmitz et al., 2019; Rock et al., 2022; Silver et al., 2013).

Integration and Mechanistic Pathways

A multimodal approach that combines aerobic, resistance, flexibility, and mind-body exercises is most effective. It improves cardiovascular fitness, muscle strength, range of motion, and mental health (Kim et al., 2009; Winters-Stone et al., 2012; Hasenoehrl et al., 2020; Buffart et al., 2012). Mechanically, these interventions reduce systemic inflammation (CRP, IL-6, TNF-α), enhance immune function through NK cell

activity, improve insulin sensitivity and estrogen metabolism, support mitochondrial and endothelial changes, and regulate the hypothalamic-pituitary-adrenal (HPA) axis, which helps to lower fatigue (García-Chico et al., 2023). These effects likely lead to better disease-free survival and overall survival in physically active patients compared to those who are sedentary (Campbell et al., 2019; McNeely et al., 2006).

4.2 Timing and Progression of Rehabilitation

The timing and progression of physical activity interventions play a crucial role in their effectiveness following surgical treatment. Early mobilization, which starts within 24 to 48 hours after surgery, has been linked to a lower risk of shoulder issues, cording, and lung complications (Lauridsen et al., 2005). During the first week, gentle range-of-motion and breathing exercises are recommended. After this initial period, patients can progress to active-assisted and resistive movements as healing allows (Shamley et al., 2007).

For cases involving axillary dissection or reconstruction, the progression should be more careful. Adjustments need to be made to prevent stress on surgical sites. If patients experience seromas, flap swelling, or nerve pain, a delay in starting structured programs may be necessary (Stubblefield & Keole, 2014). Additionally, new protocols highlight the importance of patient education, goal setting, and behavioral coaching in encouraging ongoing participation in rehabilitation (Pinto et al., 2009).

Multiple randomized controlled trials have shown that early, supervised exercise programs not only decrease postoperative complications but also reduce time to return to work and enhance long-term function (Campbell et al., 2019). Nonetheless, adherence to these programs can be limited by fatigue, depression, or fear of movement. Addressing these issues often requires collaboration between physiotherapists, psychologists, and oncology nurses (Alfano et al., 2009).

4.3 Tailoring Rehabilitation to Surgical Modality: BCT, Mastectomy, and Reconstruction

The type of surgical intervention plays a key role in how physical rehabilitation progresses for breast cancer patients. Each procedure has its own anatomical, functional, and psychological effects that need to be taken into account when creating exercise plans (Shamley et al., 2012; Kim et al., 2019).

Patients who undergo breast-conserving therapy (BCT) usually maintain better shoulder mobility and have fewer early complications. However, fibrosis from radiotherapy and adhesions under the skin can restrict soft tissue flexibility over time. Exercise plans for these patients should focus on improving thoracic mobility, stabilizing the scapula, and building endurance to combat fatigue and softness in tissue caused by radiation (McNeely et al., 2006; Shamley et al., 2007). Additionally, aerobic and resistance exercise plans have shown they can reduce systemic inflammation (e.g., IL-6, CRP), improve blood flow to muscles, and assist with microvascular changes, helping to slow down radiation-induced fibrosis and keep tissue elastic in the affected area (Dieli-Conwright & Orozco, 2015; He et al., 2024).

Patients recovering from mastectomy, especially those who had axillary lymph node dissection (ALND), often face more serious functional issues, such as limited range of motion, tight pectoral muscles, postural imbalance, and a greater risk of lymphedema (Shamley et al., 2012). Rehabilitation should begin early with both passive and active-assisted movements, progressing carefully to avoid complications like seroma or wound problems (Lauridsen et al., 2005). Attention should be given to diaphragmatic breathing, thoracic extension, and gradual strengthening of the upper limbs. Research indicates that structured early rehabilitation is safe and effective in reducing pain and restoring movement even after immediate reconstruction (Kim et al., 2019). Moreover, meta-analyses show that personalized physiotherapy programs greatly boost shoulder mobility, muscle strength, and overall physical health after mastectomy (McNeely et al., 2006).

Reconstructive surgeries, especially those using autologous flaps (e.g., TRAM, DIEP), add more complexity to rehabilitation. Issues like decreased abdominal core strength, changes in walking mechanics, or stiffness in the hip flexors should be factored into the rehabilitation plan (Garvey et al., 2006). Exercises that focus on core stabilization and control of the lower back and pelvis are essential for regaining function, especially for DIEP flap patients, who may have preserved muscle integrity but still experience nerve-related issues.

Patients might need exercise programs that address both upper and lower body movements, with modifications to accommodate healing incisions and the placement of implants (Pačarić et al., 2022). Additionally, balance, awareness of body position, and trunk control are particularly important for women with implant-based reconstruction, which can change shoulder movement patterns and cause compensatory problems (Kim et al., 2019; Guliyeva et al., 2022). Notably, recent studies show a higher rate of chronic pain and issues with body awareness after placing implants beneath the pectoral muscle, highlighting the need for tailored rehabilitation (Guliyeva et al., 2022; He et al., 2024).

Customizing rehabilitation to fit the specific surgical situation boosts safety, improves recovery, and encourages patient involvement. Research increasingly backs individualized programs that consider the complexity of the surgery, the patient's physical condition before the operation, and their psychological readiness (Silver et al., 2013). Prehabilitation tactics, such as strength assessments, shoulder evaluations, and educating patients about what to expect after surgery, can ease recovery and promote commitment to the program. Coordinating among surgeons, physiotherapists, and psycho-oncology teams is crucial for seamless care throughout survivorship.

4.4 Personalization Based on Patient Characteristics

Beyond surgical factors, individual patient attributes, such as age, body composition, baseline conditioning, and psychological resilience, play a vital role in rehabilitation outcomes. Older adults, patients with other health issues like cardiovascular disease or diabetes, and those with low activity levels before surgery may need to progress more slowly. They may also require lighter training loads and more frequent supervision to reduce the risk of overexertion, falls, or worsening symptoms (Cheville et al., 2009). Functional deficits often go unnoticed in outpatient oncology care. However, early detection and targeted intervention can improve autonomy, physical capacity, and long-term survivorship.

Psychological readiness is also critical for rehabilitation success. Patients who experience increased anxiety, depressive symptoms, or fear of movement usually show lower adherence to rehabilitation and fewer functional improvements. In these groups, behavioral strategies like motivational interviewing, cognitive reframing, and peer support have been found to improve self-efficacy and participation (Pinto et al., 2009; Sander et al., 2012). Additionally, exercise can boost mood, energy, and sleep quality, creating a positive cycle of engagement and recovery.

Social and environmental barriers must also be addressed when designing and delivering rehabilitation services. Differences in access, driven by geographic, financial, cultural, or technological issues, can disproportionately affect underserved populations. Integrating tele-rehabilitation platforms, home-based programs, and community partnerships may help broaden access and reduce inequalities in cancer care (Bluethmann et al., 2021). Tailored communication, appropriate materials, and flexible scheduling can further promote equitable engagement across various patient groups. Ultimately, customizing rehabilitation needs clinical judgment and a patient-centered approach that adapts to changing goals, varying abilities, and individual preferences throughout recovery.

High body mass index (BMI) has been linked to a greater risk of postoperative complications in breast cancer surgery. These complications include delayed wound healing, increased pain, and a higher occurrence of lymphedema (Ridner, 2009; Rock et al., 2022). Patients with high BMI often have reduced mobility and cardiorespiratory fitness, which can limit their ability to engage in traditional exercise. Therefore, low-impact methods like aquatic therapy, recumbent cycling, or seated resistance training are frequently recommended to reduce joint stress, improve circulation, and support safe rehabilitation progression. Modifications should also account for skin fold pressure, surgical incisions, and compression garment needs during physical activity. On the other hand, patients with better fitness levels before surgery may benefit from structured prehabilitation programs that include aerobic, resistance, and flexibility training before the procedure. Prehabilitation can facilitate earlier mobilization after surgery and may reduce fatigue, improve pain tolerance, and enhance psychological readiness (Toohey et al., 2023; Santa Mina et al., 2014). Research suggests that even short-term multimodal interventions lasting 2 to 4 weeks before surgery can lead to noticeable improvements in postoperative function, especially for younger patients or those undergoing less invasive procedures.

Incorporating body composition metrics and fitness assessments during initial evaluations helps customize rehabilitation plans to improve outcomes while minimizing risks. This approach also supports shared decision-making and realistic goal-setting throughout the care journey (Smith-Turchyn et al., 2016).

Psychological readiness is another key factor for rehabilitation success. Patients with high fears of movement (kinesiophobia), anxiety, or depression often show lower compliance with exercise programs and report greater limitations in daily activities (Pinto & Trunzo, 2005). Tailored psychological support, including cognitive-behavioral therapy (CBT), motivational interviewing, and structured peer support interventions, has been shown to improve both adherence and psychosocial outcomes in these populations (Rock et al., 2022). Moreover, research indicates that participation in exercise programs is heavily influenced by psychological factors, perceived benefits, and past health behaviors, especially during the survivorship phase (Kampshoff et al., 2016; Schmitz et al., 2019). Therefore, it is crucial to integrate psychological screenings and behavioral support into physical rehabilitation pathways to ensure ongoing engagement and optimize long-term recovery.

The use of wearable technology like pedometers, smartwatches, and biosensors has introduced new opportunities in exercise oncology, allowing for real-time monitoring, individual goal-setting, and behavioral reinforcement. These tools are particularly helpful in rural or resource-limited areas where access to in-person rehabilitation services may be limited (Kampshoff et al., 2016). Digital health platforms, such as mobile apps and telehealth systems, can enhance patient engagement by providing customized exercise plans, reminders, feedback, and social support features, which can improve adherence and satisfaction. Studies suggest that when combined with motivational strategies and clinician feedback, such technologies can significantly boost physical activity among breast cancer survivors.

Beyond technology, effective rehabilitation requires a coordinated multidisciplinary approach. Collaboration among oncologists, physiotherapists, psychologists, nurses, and exercise specialists ensures that care plans address the various challenges patients face, including pain, fatigue, emotional distress, and fears of recurrence (Toohey et al., 2023). Personalized survivorship plans developed through this teamwork have been shown to enhance both functional outcomes and patient-reported quality of life (Alfano et al., 2019). Incorporating behavioral science and supportive care principles into rehabilitation models is essential for achieving long-term success in breast cancer care.

5 Future Directions and Clinical Implications

As oncological rehabilitation changes, a combined approach to physical activity and surgical care for breast cancer patients is becoming more recognized. Future efforts need to tackle issues related to personalization, accessibility, and understanding the mechanisms involved. This will help maximize the benefits of exercise during all stages of recovery.

5.1 Integrating Prehabilitation into Surgical Pathways

The idea of prehabilitation, which involves preparing patients physically and mentally before surgery, has shown promise in improving recovery outcomes. New trials suggest that doing aerobic and resistance exercises before surgery can lower the chance of complications, help maintain muscle mass, and enable a quicker return to normal function (Toohey et al., 2023; Santa Mina et al., 2014). These approaches also connect to better long-term engagement in physical activities and more positive psychosocial recovery paths (Kampshoff et al., 2016).

Customized prehabilitation plans should be included in comprehensive pre-surgical evaluations, especially for high-risk groups like older patients, those with a high BMI, or people needing complex reconstructive surgery (Santa Mina et al., 2014; Silver & Baima, 2013). Adding nutritional advice and stress-reduction methods could further improve preparation for surgery and lower the risk of problems during the procedure (Carli & Scheede-Bergdahl, 2015; Rock et al., 2022; Pinto & Trunzo, 2005). Making prehabilitation a standard part of cancer care involves coordinating systems and establishing clear referral options within oncology services (Alfano et al., 2019).

5.2 Advances in Exercise Oncology Research

Despite growing evidence that structured physical activity supports recovery in breast cancer, important questions remain about the best dose-response relationships, safety limits, and long-term effects in different patient groups. Recent studies using wearable technology, biomarkers, and imaging are starting to clarify how exercise affects tumor biology, systemic inflammation, and immune function (Jones et al., 2012).

The emerging field of precision exercise medicine, which customizes activity prescriptions to individual genetic, metabolic, and behavioral profiles, shows great potential. Future trials should focus on identifying factors that affect responsiveness, barriers to sticking with exercise, and how physical activity may influence recurrence risk and overall survival (Schmitz et al., 2010a; Schmitz et al., 2010b; Campbell et al., 2019).

Additionally, expanding research among underrepresented groups, including low-income and rural communities, is crucial for ensuring fair implementation of evidence-based exercise programs (Kampshoff et al., 2016; Smith-Turchyn et al., 2016).

5.3 Clinical Implementation and Health Systems Integration

Translating exercise oncology into routine care needs structural changes at multiple levels. Oncology clinics must use standardized screening for functional impairments, physical inactivity, and exercise readiness. They should refer patients to trained physiotherapists or exercise physiologists (Schmitz et al., 2019).

Interdisciplinary rehabilitation teams, which include oncologists, surgeons, nurses, physiotherapists, psychologists, and nutritionists, should work together to create survivorship care plans. These plans should incorporate individual physical activity goals (Alfano et al., 2019). Health systems must also tackle logistical issues such as transportation, cost, and scheduling flexibility, which often limit participation in supervised programs (Kampshoff et al., 2016).

Digital health tools, including mobile applications, tele-rehabilitation platforms, and virtual coaching, can fill service gaps and provide scalable solutions for long-term monitoring and motivation (Schmitz et al., 2019). To ensure sustainability, national guidelines should include reimbursement options and formalize certification paths that integrate exercise into standard oncology care.

6. Conclusions

The addition of structured physical activity in breast cancer care should be seen as a crucial part of modern cancer treatment. Many studies show how important physical rehabilitation is for reducing postoperative issues, such as lymphedema, pain, and muscle problems. It also helps with mental health, body image, and long-term independence.

The type of surgery, whether it is breast-conserving therapy, mastectomy, or reconstructive surgery, greatly influences the timing and approach to rehabilitation. This requires personalized plans that consider the surgical impact, the patient's other health concerns, and their social situation. A tailored rehabilitation program is necessary to support recovery and long-term health outcomes.

In the future, advancements in exercise oncology, the use of prehabilitation protocols, and the merger of different rehabilitation methods offer promising paths to improve recovery, lower the chance of recurrence, and enhance survivorship. These changes indicate a shift in thinking, where physical activity is seen as a main treatment method included throughout all stages of cancer care.

To fully achieve this potential, ongoing research, changes in health policies, and the sharing of effective exercise programs in various clinical settings are essential. Helping patients with evidence-based movement strategies can reshape standards of care in surgical oncology.

Disclosure

Author's Contributions Statement

Conceptualization: Maciej Borowski, Natalia Śliwa, Sara Langner
Methodology: Eliza Kawalska, Joanna Jasińska, Bartosz Dądela, Szymon Gnitecki
Software: Szymon Janczura, Sara Langner, Kacper Zielonka
Check: Kacper Zielonka, Marcin Markowski, Maciej Borowski
Formal analysis: Natalia Śliwa, Joanna Jasińska, Maciej Borowski, Szymon Gnitecki
Investigation: Bartosz Dądela, Marcin Markowski, Eliza Kawalska, Szymon Janczura
Resources: Kacper Zielonka, Maciej Borowski, Bartosz Dądela, Szymon Gnitecki
Data curation: Bartosz Dądela, Marcin Markowski, Natalia Śliwa, Eliza Kawalska
Writing – rough preparation: Kacper Zielonka, Joanna Jasińska, Maciej Borowski, Marcin Markowski, Natalia Śliwa, Eliza Kawalska, Szymon Janczura,
Writing – review and editing: Sara Langner, Szymon Gnitecki, Bartosz Dądela
Visualization: Natalia Śliwa, Joanna Jasińska, Szymon Janczura, Bartosz Dądela
Supervision: Maciej Borowski, Kacper Zielonka, Eliza Kawalska
Project administration: Maciej Borowski, Sara Langner

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REFERENCES

1. Filho AM, Laversanne M, Ferlay J, et al. The GLOBOCAN 2022 cancer estimates: Data sources, methods, and a snapshot of the cancer burden worldwide. Int J Cancer. 2025;156(7):1336-1346. doi:10.1002/ijc.35278
2. Janz NK, Mujahid M, Lantz PM, et al. Population-based study of the relationship of treatment and sociodemographics on quality of life for early stage breast cancer. Qual Life Res. 2005;14(6):1467-1479. doi:10.1007/s11136-005-0288-6
3. Silver JK, Baima J, Mayer RS. Impairment-driven cancer rehabilitation: an essential component of quality care and survivorship. CA Cancer J Clin. 2013;63(5):295-317. doi:10.3322/caac.21186
4. Veronesi U, Cascinelli N, Mariani L, et al. Twenty-year follow-up of a randomized study comparing breast-conserving surgery with radical mastectomy for early breast cancer. N Engl J Med. 2002;347(16):1227-1232. doi:10.1056/NEJMoa020989
5. Shamley D, Lascurain-Aguirrebeña I, Oskrochi R, Srinaganathan R. Shoulder morbidity after treatment for breast cancer is bilateral and greater after mastectomy. Acta Oncol. 2012;51(8):1045-1053. doi:10.3109/0284186X.2012.695087
6. Schmitz KH, Courneya KS, Matthews C, et al. American College of Sports Medicine roundtable on exercise guidelines for cancer survivors. Med Sci Sports Exerc. 2010a;42(7):1409-1426. doi:10.1249/MSS.0b013e3181e0c112
7. Rietman JS, Geertzen JH, Hoekstra HJ, et al. Long term treatment related upper limb morbidity and quality of life after sentinel lymph node biopsy for stage I or II breast cancer. Eur J Surg Oncol. 2006;32(2):148-152. doi:10.1016/j.ejso.2005.11.008
8. Campbell KL, Winters-Stone KM, Wiskemann J, et al. Exercise Guidelines for Cancer Survivors: Consensus Statement from International Multidisciplinary Roundtable. Med Sci Sports Exerc. 2019;51(11):2375-2390. doi:10.1249/MSS.0000000000002116
9. Hayes SC, Spence RR, Galvão DA, Newton RU. Australian Association for Exercise and Sport Science position stand: optimising cancer outcomes through exercise. J Sci Med Sport. 2009;12(4):428-434. doi:10.1016/j.jsams.2009.03.002
10. McNeely ML, Campbell K, Ospina M, et al. Exercise interventions for upper-limb dysfunction due to breast cancer treatment. Cochrane Database Syst Rev. 2010;(6):CD005211. doi:10.1002/14651858.CD005211.pub2
11. Courneya KS, Segal RJ, Mackey JR, et al. Effects of aerobic and resistance exercise in breast cancer patients receiving adjuvant chemotherapy: a multicenter randomized controlled trial. J Clin Oncol. 2007;25(28):4396-4404. doi:10.1200/JCO.2006.08.2024
12. Johansson K, Tibe K, Weibull A, Newton RC. Low intensity resistance exercise for breast cancer patients with arm lymphedema with or without compression sleeve. Lymphology. 2005;38(4):167-180.
13. DiSipio T, Rye S, Newman B, Hayes S. Incidence of unilateral arm lymphoedema after breast cancer: a systematic review and meta-analysis. Lancet Oncol. 2013;14(6):500-515. doi:10.1016/S1470-2045(13)70076-7
14. Jones LW, Alfano CM. Exercise-oncology research: past, present, and future. Acta Oncol. 2013;52(2):195-215. doi:10.3109/0284186X.2012.742564
15. Dieli-Conwright CM, Orozco BZ. Exercise after breast cancer treatment: current perspectives. Breast Cancer (Dove Med Press). 2015;7:353-362. doi:10.2147/BCTT.S82039
16. He X, Ji J, Qdaisat A, Esteva FJ, Yeung SJ. Long-term overall survival of patients who undergo breast-conserving therapy or mastectomy for early operable HER2-positive breast cancer after preoperative systemic therapy: an observational cohort study. Lancet Reg Health Am. 2024;32:100712. doi:10.1016/j.lana.2024.100712
17. Kim KH, Yeo SM, Cheong IY, Kim Y, Jeon BJ, Hwang JH. Early Rehabilitation after Total Mastectomy and Immediate Reconstruction with Tissue Expander Insertion in Breast Cancer Patients: A Retrospective Case-control Study. J Breast Cancer. 2019;22(3):472-483. doi:10.4048/jbc.2019.22.e40
18. Vohra LM, Javed SM, Jabeen D, Abidi SS, Tahseen MU. Quality of life of breast cancer survivors: a comparison of breast conserving surgery versus total mastectomy with and without immediate reconstruction: a prospective cohort study. Ann Med Surg (Lond). 2023;85(5):1513-1517. doi:10.1097/MS9.0000000000000607
19. McNeely ML, Campbell KL, Rowe BH, Klassen TP, Mackey JR, Courneya KS. Effects of exercise on breast cancer patients and survivors: a systematic review and meta-analysis. CMAJ. 2006;175(1):34-41. doi:10.1503/cmaj.051073

20. Schmitz KH, Campbell AM, Stuiver MM, et al. Exercise is medicine in oncology: Engaging clinicians to help patients move through cancer. CA Cancer J Clin. 2019;69(6):468-484. doi:10.3322/caac.21579
21. Dauplat J, Kwiatkowski F, Rouanet P, et al. Quality of life after mastectomy with or without immediate breast reconstruction. Br J Surg. 2017;104(9):1197-1206. doi:10.1002/bjs.10537
22. Pačarić S, Orkić Ž, Babić M, et al. Impact of Immediate and Delayed Breast Reconstruction on Quality of Life of Breast Cancer Patients. Int J Environ Res Public Health. 2022;19(14):8546. Published 2022 Jul 13. doi:10.3390/ijerph19148546
23. Witmanowski H, Budner M. Chirurgia piersi. Warszawa: PZWL; 2024.
24. National Cancer Institute. Breast Cancer Treatment (PDQ®)–Health Professional Version. Bethesda, MD: National Cancer Institute; 2024 [cited 2025 Jun 20]. Available from: https://www.cancer.gov/types/breast/hp/breast-treatment-pdq
25. Carr HM, Patel RA, Beederman MR, Maassen NH, Hanson SE. Risk factors for upper extremity impairment after mastectomy: A single institution retrospective review. Plast Reconstr Surg Glob Open. 2024;12(7):e5684. doi:10.1097/GOX.0000000000005684
26. Bourgeois JF, Gourgou S, Kramar A, Lagarde JM, Gall Y, Guillot B. Radiation-induced skin fibrosis after treatment of breast cancer: profilometric analysis. Skin Res Technol. 2003;9(1):39-42. doi:10.1034/j.1600-0846.2003.00357.x
27. Williams NR, Williams S, Kanapathy M, Naderi N, Vavourakis V, Mosahebi A. Radiation-induced fibrosis in breast cancer: A protocol for an observational cross-sectional pilot study for personalised risk estimation and objective assessment. Int J Surg Protoc. 2019;14:9-13. doi:10.1016/j.isjp.2019.02.002
28. Harris SR. Brachial plexopathy after breast cancer: A persistent late effect of radiotherapy. PM R. 2024;16(1):85-91. doi:10.1002/pmrj.13007
29. Nava MB, Benson JR, Audretsch W, et al. International multidisciplinary expert panel consensus on breast reconstruction and radiotherapy. Br J Surg. 2019;106(10):1327-1340. doi:10.1002/bjs.11256
30. Vilholm OJ, Cold S, Rasmussen L, Sindrup SH. The postmastectomy pain syndrome: an epidemiological study on the prevalence of chronic pain after surgery for breast cancer. Br J Cancer. 2008;99(4):604-610. doi:10.1038/sj.bjc.6604534
31. Wu X, Wang J, Cofie R, Kaminga AC, Liu A. Prevalence of Posttraumatic Stress Disorder among Breast Cancer Patients: A Meta-analysis. Iran J Public Health. 2016;45(12):1533-1544.
32. McLaughlin SA, Wright MJ, Morris KT, et al. Prevalence of lymphedema in women with breast cancer 5 years after sentinel lymph node biopsy or axillary dissection: objective measurements [published correction appears in J Clin Oncol. 2010 Apr 1;28(10):1808]. J Clin Oncol. 2008;26(32):5213-5219. doi:10.1200/JCO.2008.16.3725
33. Lauridsen MC, Christiansen P, Hessov I. The effect of physiotherapy on shoulder function in patients surgically treated for breast cancer: a randomized study. Acta Oncol. 2005;44(5):449-457. doi:10.1080/02841860510029905
34. Jagsi R, Jiang J, Momoh AO, et al. Complications After Mastectomy and Immediate Breast Reconstruction for Breast Cancer: A Claims-Based Analysis. Ann Surg. 2016;263(2):219-227. doi:10.1097/SLA.0000000000001177
35. Guliyeva G, Torres RA, Avila FR, Kaplan JL, Lu X, Forte AJ. The impact of implant-based reconstruction on persistent pain after breast cancer surgery: A systematic review. J Plast Reconstr Aesthet Surg. 2022;75(2):519-527. doi:10.1016/j.bjps.2021.09.079
36. Garvey PB, Buchel EW, Pockaj BA, et al. DIEP and pedicled TRAM flaps: a comparison of outcomes. Plast Reconstr Surg. 2006;117(6):1711-1721. doi:10.1097/01.prs.0000210679.77449.7d
37. Guinier C, de Clermont-Tonnerre E, Tay JQ, Ng ZY, Cetrulo CL Jr, Lellouch AG. The deep inferior epigastric artery perforator flap: a narrative review on its various uses in non-breast reconstruction. Ann Transl Med. 2023;11(2):130. doi:10.21037/atm-22-2623
38. Sander AP, Wilson J, Izzo N, Mountford SA, Hayes KW. Factors that affect decisions about physical activity and exercise in survivors of breast cancer: a qualitative study. Phys Ther. 2012;92(4):525-536. doi:10.2522/ptj.20110115
39. Nesvold IL, Dahl AA, Løkkevik E, Mengshoel AM, Fosså SD. Arm and shoulder morbidity in breast cancer patients after breast-conserving therapy versus mastectomy. Acta Oncol. 2008;47(5):835-842. doi:10.1080/02841860801961257
40. Harrington S, Padua D, Battaglini C, Michener LA. Upper extremity strength and range of motion and their relationship to function in breast cancer survivors. Physiother Theory Pract. 2013;29(7):513-520. doi:10.3109/09593985.2012.757683
41. Koehler LA, Haddad TC, Hunter DW, Tuttle TM. Axillary web syndrome following breast cancer surgery: symptoms, complications, and management strategies. Breast Cancer (Dove Med Press). 2018;11:13-19. Published 2018 Dec 20. doi:10.2147/BCTT.S146635
42. Fu MR, Axelrod D, Cleland CM, et al. Symptom report in detecting breast cancer-related lymphedema. Breast Cancer (Dove Med Press). 2015;7:345-352. doi:10.2147/BCTT.S87854
43. Brown JC, Troxel AB, Schmitz KH. Safety of weightlifting among women with or at risk for breast cancer-related lymphedema: musculoskeletal injuries and health care use in a weightlifting rehabilitation trial. Oncologist. 2012;17(8):1120-1128. doi:10.1634/theoncologist.2012-0035

44. Cormie P, Pumpa K, Galvão DA, et al. Is it safe and efficacious for women with lymphedema secondary to breast cancer to lift heavy weights during exercise: a randomised controlled trial. J Cancer Surviv. 2013;7(3):413-424. doi:10.1007/s11764-013-0284-8
45. Hasenoehrl T, Palma S, Ramazanova D, et al. Resistance exercise and breast cancer-related lymphedema-a systematic review update and meta-analysis. Support Care Cancer. 2020;28(8):3593-3603. doi:10.1007/s00520-020-05521-x
46. Singh B, Disipio T, Peake J, Hayes SC. Systematic Review and Meta-Analysis of the Effects of Exercise for Those With Cancer-Related Lymphedema. Arch Phys Med Rehabil. 2016;97(2):302-315.e13. doi:10.1016/j.apmr.2015.09.012
47. Andersen KG, Kehlet H. Persistent pain after breast cancer treatment: a critical review of risk factors and strategies for prevention. J Pain. 2011;12(7):725-746. doi:10.1016/j.jpain.2010.12.005
48. Stubblefield MD, Keole N. Upper body pain and functional disorders in patients with breast cancer. PM R. 2014;6(2):170-183. doi:10.1016/j.pmrj.2013.08.605
49. Mustian KM, Alfano CM, Heckler C, et al. Comparison of Pharmaceutical, Psychological, and Exercise Treatments for Cancer-Related Fatigue: A Meta-analysis. JAMA Oncol. 2017;3(7):961-968. doi:10.1001/jamaoncol.2016.6914
50. Alfano CM, Day JM, Katz ML, et al. Exercise and dietary change after diagnosis and cancer-related symptoms in long-term survivors of breast cancer: CALGB 79804. Psychooncology. 2009;18(2):128-133. doi:10.1002/pon.1378
51. Kim SH, Song YK, Han J, et al. Pro-inflammatory Cytokine Levels and Cancer-related Fatigue in Breast Cancer Survivors: Effects of an Exercise Adherence Program [published correction appears in J Breast Cancer. 2020 Sep 03;23(5):574-575. doi: 10.4048/jbc.2020.23.e49.]. J Breast Cancer. 2020;23(2):205-217. doi:10.4048/jbc.2020.23.e22
52. Rock CL, Thomson CA, Sullivan KR, et al. American Cancer Society nutrition and physical activity guideline for cancer survivors. CA Cancer J Clin. 2022;72(3):230-262. doi:10.3322/caac.21719
53. Ridner SH. The psycho-social impact of lymphedema. Lymphat Res Biol. 2009;7(2):109-112. doi:10.1089/lrb.2009.0004
54. Schmitz KH, Ahmed RL, Troxel AB, et al. Weight lifting for women at risk for breast cancer-related lymphedema: a randomized trial. JAMA. 2010b;304(24):2699-2705. doi:10.1001/jama.2010.1837
55. Kim CJ, Kang DH, Park JW. A meta-analysis of aerobic exercise interventions for women with breast cancer. West J Nurs Res. 2009;31(4):437-461. doi:10.1177/0193945908328473
56. Winters-Stone KM, Dobek J, Bennett JA, Nail LM, Leo MC, Schwartz A. The effect of resistance training on muscle strength and physical function in older, postmenopausal breast cancer survivors: a randomized controlled trial. J Cancer Surviv. 2012;6(2):189-199. doi:10.1007/s11764-011-0210-x
57. Cheema BS, Kilbreath SL, Fahey PP, Delaney GP, Atlantis E. Safety and efficacy of progressive resistance training in breast cancer: a systematic review and meta-analysis. Breast Cancer Res Treat. 2014;148(2):249-268. doi:10.1007/s10549-014-3162-9
58. Schmitz KH, Ahmed RL, Hannan PJ, Yee D. Safety and efficacy of weight training in recent breast cancer survivors to alter body composition, insulin, and insulin-like growth factor axis proteins. Cancer Epidemiol Biomarkers Prev. 2005;14(7):1672-1680. doi:10.1158/1055-9965.EPI-04-0736
59. Buffart LM, van Uffelen JG, Riphagen II, et al. Physical and psychosocial benefits of yoga in cancer patients and survivors, a systematic review and meta-analysis of randomized controlled trials. BMC Cancer. 2012;12:559. Published 2012 Nov 27. doi:10.1186/1471-2407-12-559
60. Cramer H, Lange S, Klose P, Paul A, Dobos G. Yoga for breast cancer patients and survivors: a systematic review and meta-analysis. BMC Cancer. 2012;12:412. Published 2012 Sep 18. doi:10.1186/1471-2407-12-412
61. García-Chico C, López-Ortiz S, Peñín-Grandes S, et al. Physical Exercise and the Hallmarks of Breast Cancer: A Narrative Review. Cancers (Basel). 2023;15(1):324. Published 2023 Jan 3. doi:10.3390/cancers15010324
62. Shamley DR, Srinanaganathan R, Weatherall R, et al. Changes in shoulder muscle size and activity following treatment for breast cancer. Breast Cancer Res Treat. 2007;106(1):19-27. doi:10.1007/s10549-006-9466-7
63. Pinto BM, Rabin C, Dunsiger S. Home-based exercise among cancer survivors: adherence and its predictors. Psychooncology. 2009;18(4):369-376. doi:10.1002/pon.1465
64. Cheville AL, Beck LA, Petersen TL, Marks RS, Gamble GL. The detection and treatment of cancer-related functional problems in an outpatient setting. Support Care Cancer. 2009;17(1):61-67. doi:10.1007/s00520-008-0461-x
65. Bluethmann SM, Alfano CM, Peck BM, et al. Harnessing the potential of technology to support cancer survivorship care planning: A review of current tools and future directions. Cancer. 2021;127(9):1375-1386. doi:10.1002/cncr.33305
66. Toohey K, Hunter M, McKinnon K, et al. A systematic review of multimodal prehabilitation in breast cancer. Breast Cancer Res Treat. 2023;197(1):1-37. doi:10.1007/s10549-022-06759-1
67. Santa Mina D, Clarke H, Ritvo P, et al. Effect of total-body prehabilitation on postoperative outcomes: a systematic review and meta-analysis. Physiotherapy. 2014;100(3):196-207. doi:10.1016/j.physio.2013.08.008

68. Smith-Turchyn J, Richardson J, Tozer R, McNeely M, Thabane L. Physical Activity and Breast Cancer: A Qualitative Study on the Barriers to and Facilitators of Exercise Promotion from the Perspective of Health Care Professionals. Physiother Can. 2016;68(4):383-390. doi:10.3138/ptc.2015-84
69. Pinto BM, Trunzo JJ. Health behaviors during and after a cancer diagnosis [published correction appears in Cancer. 2006 Apr 1;106(7):1641]. Cancer. 2005;104(11 Suppl):2614-2623. doi:10.1002/cncr.21248
70. Kampshoff CS, van Mechelen W, Schep G, et al. Participation in and adherence to physical exercise after completion of primary cancer treatment. Int J Behav Nutr Phys Act. 2016;13(1):100. doi:10.1186/s12966-016-0425-3
71. Alfano CM, Mayer DK, Bhatia S, et al. Implementing personalized pathways for cancer follow-up care in the United States: Proceedings from an American Cancer Society-American Society of Clinical Oncology summit. CA Cancer J Clin. 2019;69(3):234-247. doi:10.3322/caac.21558
72. Silver JK, Baima J. Cancer prehabilitation: an opportunity to decrease treatment-related morbidity, increase cancer treatment options, and improve physical and psychological health outcomes. Am J Phys Med Rehabil. 2013;92(8):715-727. doi:10.1097/PHM.0b013e31829b4afe.
73. Carli F, Scheede-Bergdahl C. Prehabilitation to enhance perioperative care. Anesthesiol Clin. 2015;33(1):17-33. doi:10.1016/j.anclin.2014.11.002
74. Jones LW, Antonelli J, Masko EM, et al. Exercise modulation of the host-tumor interaction in an orthotopic model of murine prostate cancer. J Appl Physiol (1985). 2012;113(2):263-272. doi:10.1152/japplphysiol.01575.2011