Review

Lymphoedema after Breast Cancer Surgery: Anatomical Background and Physiotherapy Interventions

Juvančič Eva[1], Kodrnja Natalija[1], Šuc Tjaša[1], Tomasino Kaja[1], Boc Anja[2,*]

1. University of Ljubljana, Faculty of Health Sciences, Ljubljana, Slovenia
2. University of Ljubljana, Faculty of Medicine, Ljubljana, Slovenia

* Correspondence: Anja Boc: anja.boc@mf.uni-lj.si

Citation: Juvančič E, Kodrnja N, Šuc T, Tomasino K, Boc A. Lymphoedema after breast cancer surgery: anatomical background and physiotherapy interventions. Proceedings of Socratic Lectures. **2026**, 14, 52-63. https://doi.org/10.55295/PSL.14.2026.I7

Publisher's Note: UL ZF stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Abstract:
Breast cancer-related lymphoedema (BCRL) is a common long-term complication following breast cancer surgery, resulting from impaired lymphatic transport due to surgical and radiotherapeutic damage to lymphatic structures. The anatomical interconnection between lymphatic drainage of the breast and the upper limb plays a central role in the development of lymphoedema after axillary interventions. Lymphatic dysfunction leads to the accumulation of protein-rich interstitial fluid, contributing to the progression of a chronic condition characterised by physical, functional, and psychosocial impairments. Physiotherapy represents a cornerstone of conservative management, with complex decongestive therapy incorporating compression therapy, manual lymphatic drainage, therapeutic exercise, skin care, and patient education. Current evidence supports the safety and benefits of appropriately prescribed exercise, while adjunct interventions may provide additional supportive effects. An interdisciplinary, evidence-based approach with active patient participation is essential to optimise prevention, management, and long-term outcomes of BCRL in breast cancer survivors.

Keywords: Breast cancer; Breast cancer-related lymphoedema; Lymphatic system; Physiotherapy; upper limb; Complex decongestive therapy

1. Introduction

Breast cancer is one of the most prevalent malignancies worldwide and remains a major public health concern due to its high incidence and long-term impact on morbidity among women (Hing et al., 2024; Pappalardo et al., 2021). In Slovenia, breast cancer represents the most prevalent malignancy in women, accounting for 24.5% of all female cancers in 2022, with a projected incidence of 136–154 per 100,000 women in 2025 (Cancer in Slovenia 2022, 2025). Advances in early detection and oncological treatment have substantially improved survival rates, leading to a growing population of breast cancer survivors and an increased attention to long-term treatment-related complications affecting functional capacity and quality of life (Hing et al., 2024).

Surgical treatment constitutes a mainstay of breast cancer management and is frequently combined with adjuvant therapies such as radiotherapy, chemotherapy, and endocrine therapy. Common surgical approaches include breast-conserving surgery or mastectomy, often accompanied by axillary procedures for staging and local disease control. Although essential for favourable oncological outcomes, axillary interventions may disrupt lymphatic vessels and lymph nodes, thereby increasing the risk of postoperative lymphatic complications (International Society of Lymphology, 2024; Shen et al., 2022).

Breast cancer-related lymphoedema (BCRL) represents one of the most frequent and clinically significant long-term complications following breast cancer surgery. It develops due to impaired lymphatic transport capacity caused by surgical and radiotherapeutic damage and may occur months or years after treatment completion, most commonly affecting the upper limb on the treated side (Kataru et al., 2019; International Society of Lymphology, 2024; Shen et al., 2022;). In this context, the present contribution aims to outline the anatomical background of the lymphatic system of the breast and upper limb, describe the pathophysiology and clinical features of BCRL, and examine the role of physiotherapy interventions in its management, highlighting the importance of interdisciplinary and evidence-based care.

2. Design of the Review

A literature review was conducted through an analysis of scientific publications addressing BCRL. The aim was to synthesise and integrate key findings on the development of lymphoedema, the role of the lymphatic system, and the contribution of physiotherapy interventions in the prevention and management of this condition into a comprehensive and coherent overview.

The literature search was conducted using the PubMed and ResearchGate databases. Search terms included breast cancer, lymphoedema, breast cancer-related lymphoedema, lymphatic system, physiotherapy, and complex decongestive therapy, as well as their combinations. Additionally, data about the prevalence of breast cancer for the Slovenian population were extracted from the Slovenian Cancer Registry.

The review includes scientific articles published from 2001 onwards, comprising original research articles, review articles, and systematic reviews relevant to the topic. Sources were selected based on their content relevance and their contribution to understanding lymphoedema following breast cancer surgery and its physiotherapeutic management. No formal quality assessment or risk-of-bias evaluation was performed, which represents a limitation of this narrative review.

3. Anatomical background of the lymphatic system of the breast and upper limb

3.1. The lymphatic system – general characteristics

The cardiovascular system, comprising the heart and an extensive network of blood vessels, is among the first functional organ systems to develop during mammalian embryogenesis (Janardhan et al., 2024). The development of the lymphatic system occurs concurrently with that of the blood vasculature, through the process of lymphangiogenesis. The lymphatic system constitutes an essential component of the mammalian vascular system and is organized as a hierarchical, multilevel network of lymphatic vessels originating from blind-ended capillaries. In addition to lymphatic vessels, the system includes lymph nodes, which harbour T and B immune cells, as well as other mucosa-associated lymphoid tissues such as the tonsils, adenoids, Peyer's patches in the small intestine, and the appendix (Oliver et al., 2020).

Functionally, the lymphatic system plays a central role in the removal of excess protein-rich interstitial fluid and its return to the bloodstream, in the transport of immune cells from peripheral tissues to lymph nodes for antigen presentation and immune surveillance, and in the transfer of lipid-rich chyle from the gastrointestinal tract into the circulation. In doing so, it makes a substantial contribution to the maintenance of fluid balance, effective immune defence, and overall physiological homeostasis (Janardhan et al., 2024).

Beyond its role as a drainage system, the lymphatic system also possesses active physiological mechanisms that enable efficient lymph flow. The walls of larger lymphatic vessels contain smooth muscle cells with intrinsic contractile activity, which rhythmically propel lymph in a proximal direction independently of the cardiovascular system. This mechanism is especially critical in the limbs, where lymphatic transport continuously counteracts gravitational forces. Unidirectional flow is further ensured by valves within the lymphatic vessels, which prevent retrograde movement of lymph and thereby maintain the efficiency of lymphatic drainage. In addition to fluid transport, the lymphatic system facilitates the movement of macromolecules, cytokines, and immune signalling molecules that cannot be directly removed from the interstitial space by the blood circulation, further underscoring its role in regulating the tissue microenvironment (Swartz, 2001).

3.2. Lymphatic drainage of the breast and upper limb

The lymphatic drainage of the breast represents a complex, hierarchical, and multidirectional network that is central to the regional spread and staging of breast cancer. Most (75–90%) of the lymphatic drainage of the breast occurs via the ipsilateral axillary lymph nodes, which constitute the primary nodal basin for metastatic dissemination in the majority of patients. Nearly all lymphatic vessels of the breast course along a subdermal plane toward the axilla, where lymph typically first drains to one or a small number of sentinel lymph nodes located near the lateral border of the pectoralis major muscle (Grouthamel, 2023).

Lymphatic vessels originate as blind-ended capillaries within both superficial cutaneous and deep parenchymal plexuses and subsequently converge into collecting vessels equipped with valves and smooth muscle, ensuring unidirectional lymph transport. Superficial lymphatics of the nipple and areola form a dense network of pre-collectors known as the subareolar lymphatic plexus (Sappey's plexus), while lymphatics within the breast parenchyma arise from the interlobular connective tissue and the walls of the lactiferous ducts (Grouthamel, 2023). This convergence within the subareolar plexus provides the anatomical basis for sentinel lymph node mapping and explains the shared nodal drainage observed across different breast quadrants (Zhang-Yin et al., 2024).

The axillary lymph nodes are classically divided into six interconnected groups: apical (subclavicular), lateral (brachial or humeral), central, posterior (subscapular or scapular), anterior (pectoral or external mammary), and interpectoral (Rotter's) nodes. The apical nodes, comprising approximately 8–12 nodes, are located between the superior border of the pectoralis minor muscle and the clavicle and receive lymph from all other axillary nodal groups. From here, lymph drains into the subclavian lymphatic trunk, which empties into the thoracic duct on the left side and the right lymphatic duct on the right. Lateral nodes (4–6 nodes), situated medial and posterior to the axillary vein, primarily drain the upper limb and empty into the apical nodes. Central nodes (4–5 nodes), located deep to the pectoralis minor within axillary adipose tissue, receive lymph from the breast as well as from the brachial, pectoral, and subscapular groups. Posterior nodes (5–7 nodes) along the lateral border of the scapula drain the posterior neck, shoulder, and trunk, while anterior nodes (5–6 nodes) along the lateral thoracic vessels receive lymph from the lateral breast and anterior abdominal wall and drain into the central group. Interpectoral (Rotter's) nodes, consisting of 1–4 nodes between the pectoralis major and minor muscles, receive lymph directly from the breast and drain into the apical and pectoral nodes; although sometimes classified as axillary nodes, they are anatomically distinct from the main axillary nodal chain (Grouthamel, 2023).

A variable proportion of lymphatic drainage, particularly from the medial quadrants of the breast, follows deeper pathways that perforate the deep fascia and drain into the parasternal (internal mammary) lymph nodes located along the internal thoracic vessels. These nodes have been identified as sentinel lymph nodes in a substantial subset of patients and are increasingly recognised for their prognostic and therapeutic relevance (Eckert et al., 2024). In addition to the principal axillary and internal mammary pathways, sporadic drainage to interpectoral, subscapular, subclavicular, supraclavicular, or even contralateral parasternal lymph nodes may occur, highlighting the anatomical variability of breast lymphatic drainage (Grouthamel, 2023).

In breast cancer, the lymphatic system plays a particularly important role, as malignant cells frequently exploit lymphatic pathways to spread from the primary tumour. Lymph nodes, especially sentinel lymph nodes, represent the first site of metastatic dissemination in most cases of early-stage disease, although in some instances tumour cells may also enter the bloodstream directly. Studies based on sentinel lymph node models in melanoma and breast cancer demonstrate that early lymphatic spread generally occurs in a stepwise manner along predictable anatomical pathways, a principle that underpins modern diagnostic and therapeutic strategies in oncological practice (Leong et al., 2022).

In recent years, increasing attention has been directed toward the relationship between lymphatic drainage of the breast and that of the upper limb. Anatomical and clinical studies indicate a significant degree of overlap between these two systems within the axillary region. In a proportion of breast cancer patients, lymphatic vessels from the upper limb converge into the same axillary lymph nodes that drain the breast, and in approximately two-thirds of cases, lymphatic pathways from the upper limb have been identified within the field of sentinel lymph node biopsy (Ma et al., 2019).Anatomical investigations have further demonstrated the presence of communicating lymphatic vessels between different axillary nodal groups, underscoring the functional interconnection between breast and upper limb lymphatic drainage (Cuadrado et al., 2018). These relationships have important clinical implications, as surgical interventions in the axilla –particularly lymph node biopsy or dissection – may compromise lymphatic drainage of the upper limb and increase the risk of lymphoedema. A thorough understanding of these anatomical and functional interconnections is therefore essential for surgical planning aimed at preserving lymphatic integrity and minimising postoperative complications (Cuadrado et al., 2018; Ma et al., 2019).

4. Lymphoedema after breast cancer surgery

4.1. Definition, Classification, and Epidemiology

BCRL is a chronic and progressive condition caused by impairment of the lymphatic system following breast cancer treatment. International Society of Lymphology (ISL) describes lymphoedema as a condition resulting from reduced lymph transport capacity, leading to accumulation of protein-rich fluid in the interstitial space and producing internal and/or external manifestations of lymphatic system insufficiency (ISL, 2024). In breast cancer survivors, lymphoedema may develop months or even years after surgical or radiotherapeutic intervention (Armer & Stewart, 2010).

Lymphoedema is classified as primary and secondary. Primary lymphoedema arises from congenital or hereditary abnormalities of the lymphatic system, including hypoplasia or aplasia of lymphatic vessels or nodes (ISL, 2024). In contrast, secondary lymphoedema results from acquired damage to an initially normal lymphatic system and represents the predominant form observed in breast cancer populations (Kataru et al., 2019). BCRL is most frequently associated with axillary lymph node dissection, sentinel lymph node biopsy, radiotherapy, infection, or trauma leading to lymphatic obstruction or overload (ISL, 2024; Shen et al., 2022).

The ISL classifies lymphoedema into four clinical stages. Stage 0 represents a latent state in which lymph transport is impaired without clinically detectable swelling. Stage I presents with an early, potentially reversible phase characterized by compressible oedema. Stage II is characterized by persistent swelling that does not resolve with elevation of the limb and is associated with increasing tissue fibrosis. Stage III (lymphostatic elephantiasis) involves pronounced limb enlargement, skin alterations, adipose tissue accumulation, and a higher susceptibility to recurrent infections (ISL, 2024). This staging system is widely used in clinical practice and research to describe BCRL severity and progression (Pappalardo et al., 2021).

The incidence and prevalence of BCRL vary considerably depending on diagnostic criteria, assessment methods, follow-up duration, and treatment modalities. A pooled analysis from cohort studies suggests that more than one in five breast cancer survivors develops lymphoedema, with incidence estimates ranging from 16.6% to 21.9% (DiSipio et al., 2013; Shen et al., 2022). Prevalence estimates increase with longer follow-up periods. Recent cohort data report a cumulative BCRL prevalence of 30.9%, although clinically apparent lymphoedema was observed in a smaller proportion of patients (Hing et al., 2024).

4.2. Pathophysiology

BCRL develops as a consequence of lymphatic system injury that exceeds the transport capacity required to maintain tissue fluid homeostasis (**Figure 1**). Axillary interventions and adjuvant therapies disrupt lymphatic vessels and lymph nodes, resulting in compromised lymph clearance, leading to the accumulation of interstitial fluid (ISL, 2024; Pappalardo et al., 2021).

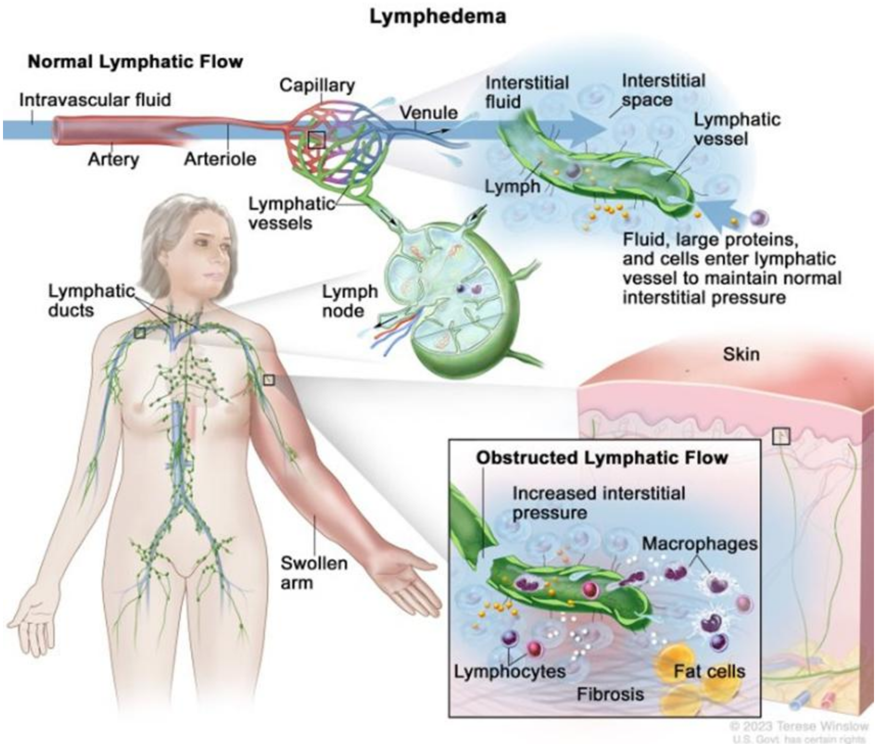

Figure 1: Pathophysiology of lymphoedema: comparison of normal and obstructed lymphatic flow. Adapted from the National Cancer Institute (NCI) Lymphedema (PDQ®)–Health Professional Version. (National Cancer Institute, 2024). Illustration © Terese Winslow, U.S. Government.

Axillary lymph node dissection represents the most significant surgical disruption to lymphatic drainage, as removal of lymph nodes and associated vessels reduces lymphatic transport capacity and compromises lymphatic outflow routes (Che Bakri et al., 2023; Pappalardo et al., 2021). Although sentinel lymph node biopsy is less extensive, it may still precipitate BCRL, particularly when combined with other risk factors such as radiotherapy (Pappalardo et al., 2021; Shen et al., 2022). Radiotherapy further exacerbates damage to lymphatic vessels and surrounding soft tissues through fibrotic changes, including reduced collecting lymphatic pumping. Although compensatory lymphangiogenesis may occur after lymphatic injury, newly formed vessels are often structurally and functionally insufficient to restore normal lymphatic drainage (Kataru et al., 2019).

Impaired lymphatic drainage leads to persistent accumulation of interstitial fluid, which initiates and sustains a local inflammatory response (Bowman & Rockson, 2024). Chronic lymph stasis promotes immune cell infiltration, including macrophages and T lymphocytes, and the release of pro-inflammatory mediators that further damage lymphatic endothelial cells and disrupt lymphatic contractile function. Rather than being a purely mechanical disorder, BCRL is now recognized as a chronic inflammatory condition in which lymphatic injury acts as an initiating event that triggers progressive pathological changes (Bowman & Rockson, 2024; Kataru et al., 2019).

Persistent inflammation promotes progressive fibrosis of lymphatic vessels and surrounding connective tissue, leading to reduced vessel compliance and irreversible impairment of lymph transport. Concomitant expansion of adipose tissue contributes to limb enlargement and further mechanical obstruction of lymphatic flow (Kataru et al., 2019). Over time, these processes result in structural and functional deterioration of the lymphatic system, increased susceptibility to recurrent infections, and the transition from potentially reversible oedema to chronic lymphoedema (Bowman & Rockson, 2024; Piller, 2020).

4.3. Risk Factors

The development of BCRL is multifactorial, resulting from an interaction between treatment-related exposures, patient-related characteristics, and postoperative or lifestyle-associated factors (Shen et al., 2022).

Treatment-related factors represent the most consistently identified determinants of BCRL. Axillary lymph node dissection is associated with a substantially higher risk compared with sentinel lymph node biopsy. The risk increases with a greater number and higher level of lymph nodes excised (Shen et al., 2022). Radiotherapy, particularly when lymph node regions are included in the radiation field, further elevates BCRL risk (Matsumoto et al., 2025; Shen et al., 2022). Docetaxel-based chemotherapy has also been identified as a contributing factor. More extensive breast surgery, such as mastectomy, compared with breast-conserving surgery, has likewise been linked to increased risk (Shen et al., 2022).

Body mass index (BMI) is the most consistently reported patient-related independent predictor, with both overweight and obesity significantly increasing the likelihood of developing lymphoedema. Postoperative weight gain further augments this risk (Shen et al., 2022). Age has shown variable associations across studies (Matsumoto et al., 2025; Shen et al., 2022). Certain comorbidities, such as hypertension, have also been identified as contributing factors in pooled analyses (Shen et al., 2022).

Postoperative complications play an important role in modifying BCRL risk. Surgical complications such as seroma formation and infection have been associated with a higher incidence of lymphoedema (Shen et al., 2022). From a lifestyle perspective, modifiable factors – particularly weight management – are emphasized as important targets for prevention, as elevated BMI and postoperative weight increase consistently correlate with higher BCRL risk (Hing et al., 2024; Shen et al., 2022). These findings emphasize the importance of integrating long-term surveillance strategies with patient education and early risk-reduction interventions (Hing et al., 2024).

4.4. Clinical Presentation and Diagnosis

The clinical presentation of BCRL is variable and may develop gradually over time. Early manifestations are often subtle and subjective, frequently preceding objectively measurable changes of limb volume. The most reported symptoms include limb swelling and sensations such as heaviness or tightness, alongside stiffness, pain, and numbness of the affected upper limb. Patients may also describe a perceived increase in limb size, puffiness, or firmness, even in the absence of clinically detectable oedema (Gursen et al., 2021).

As the condition progresses, visible limb swelling becomes more evident and may extend to the hand, forearm, upper arm, breast, or trunk on the treated side (Hayes et al., 2012). Skin and subcutaneous tissue changes can develop over time, including thickening, reduced skin elasticity, and increased tissue firmness related to fibrotic and adipose tissue alterations (ISL, 2024). Functional limitations are commonly reported and may include reduced range of motion, impaired manual dexterity, and difficulties performing daily activities, contributing to reduced quality of life. Beyond physical impairment, patients frequently experience psychological distress and social limitations associated with chronic swelling and functional dependency (Hayes et al., 2012).

Accurate management of BCRL requires a thorough understanding of disease diagnosis and severity, based on a combination of patient history and physical examination. Clinical evaluation includes review of risk factors and comorbidities, assessment of subjective symptoms and physical signs, and exclusion of alternative causes of limb swelling (Pappalardo et al., 2021). Patient-reported symptoms are increasingly recognized as a valuable diagnostic component, particularly for identifying early or subclinical lymphoedema (Gursen et al., 2021).

Objective diagnosis primarily relies on limb measurements to detect asymmetry or volume changes. Circumferential tape measurement remains the most widely used clinical method due to its simplicity, low cost, and good reliability when standardized protocols are followed. By using standardized anatomical measurement points, this method enables assessment of the distribution and localization of swelling across different limb segments. Measurements are typically performed bilaterally, with the unaffected limb serving as a reference. Limb volume may be estimated from circumference data or alternatively measured using the water displacement method. No single diagnostic threshold is universally accepted, highlighting the importance of consistent baseline and follow-up measurements for accurate detection of BCRL (Dylke, 2022).

In addition to circumferential tape measurements, instrument-based methods are increasingly used as a complementary assessment of BCRL (Dylke, 2022). Bioimpedance spectroscopy is used to estimate extracellular fluid changes and is particularly sensitive for detecting early or subclinical changes (Dylke, 2022; Shah et al., 2023). Perometry uses optoelectronic scanning to automatically calculate limb volume, providing a rapid, accurate, and highly reproducible measurement, although the requirement for specialized equipment limits its routine clinical use (Dylke, 2022; Sun et al., 2018).

5. Physiotherapy approach for lymphoedema

5.1. Aims of physiotherapy

Physiotherapy management of BCRL is based on a conservative, multimodal approach aimed at reducing oedema, improving upper limb functional capacity, and supporting long-term management. Available evidence suggests that the most effective management involves the integration of multiple complementary therapeutic interventions tailored to the individual patient (Shamoun & Ahmad, 2023).

5.2. Complex decongestive therapy

Complex decongestive therapy (CDT) plays a central role in the physiotherapy management of lymphoedema. A systematic review and meta-analysis of randomised controlled trials demonstrate that CDT leads to a clinically meaningful reduction in the volume of the affected limb and improvement in functional outcomes when delivered in a structured and long-term manner. CDT is a multimodal intervention comprising manual lymphatic drainage, compression therapy, therapeutic exercise, skin care, and patient education, with its effectiveness attributed to the concurrent and coordinated application of these components rather than to any single modality alone. Manual lymphatic drainage is incorporated within CDT protocols as a core component aimed at facilitating lymphatic flow and supporting oedema reduction during the intensive phase of treatment. Compression therapy represents a key element of CDT, as it plays a central role in maintaining achieved limb volume reduction and preventing reaccumulation of lymphatic fluid (Shamoun & Ahmad, 2023). Skin care is described in the literature as an integral component of CDT and is consistently included within treatment protocols as part of patient education and self-management. Its primary purpose is the prevention of skin damage and infection rather than a direct contribution to limb oedema reduction (Shamoun & Ahmad, 2023; Torres-Lacomba et al., 2020). A comparative clinical study showed that compression bandaging (**Figure 2**) was more effective in reducing oedema than kinesiotaping, although the latter was perceived as more comfortable by some patients (Torres-Lacomba et al., 2020).

Figure 2: Compression bandaging of the upper limb in BCRL. From (Yaman et al., 2021, CC BY-NC 4.0 License).

5.3. Therapeutic exercise

Therapeutic exercise represents an important active component of the physiotherapy programme. Systematic reviews indicate that physical exercise, including resistance training, does not exacerbate lymphoedema and does not lead to an increase in upper limb volume in women following breast cancer treatment (Baumann et al., 2018). Further evidence confirms that resistance exercise does not negatively affect the circumference or volume of the affected limb, while contributing to improvements in muscle strength and physical performance when progressively loaded and individually tailored (Hasenoehrl et al., 2020). An evidence-based review of guidelines additionally reports consensus regarding the safety and effectiveness of resistance exercise as part of a comprehensive rehabilitation programme for BCRL (Wang et al., 2023).

5.4. Additional physiotherapy interventions

Among adjunct physiotherapy interventions, kinesiotaping is frequently discussed in the literature. A systematic review indicates that kinesiotaping does not provide a consistent reduction in upper limb volume when used as a standalone intervention. Some studies have reported improvement in functional outcomes and perceived quality of life (Marotta et al., 2023). These findings are further supported by a more recent meta-analysis, which highlights the heterogeneity of results and methodological differences across studies (Yang et al., 2024). Randomised clinical trials additionally suggest that, in the early stages of lymphoedema, kinesiotaping may be comparable to compression garments in terms of limb circumference reduction and may be associated with lower levels of pain (Ozsoy-Unubol et al., 2019).

Hydrotherapy, or therapeutic exercise performed in water, is described in recent literature as an adjunct physiotherapy intervention in the rehabilitation of women following breast cancer treatment, including those with BCRL. A systematic review with meta-analysis reports that aquatic exercise has a positive effect on quality of life, pain reduction, range of motion, and certain symptoms associated with lymphoedema; however, these effects are predominantly short-term and supported by a low level of evidence certainty (Silva et al., 2025). Aquatic therapy represents a component of physiotherapeutic intervention for lymphoedema following breast cancer surgery. In a prospective, single-blind randomized controlled trial, an 8-week programme of aqua therapy resistance exercises performed three times per week resulted in significant reductions in limb volume and pain intensity, as well as improvements in shoulder range of motion, compared with a land-based exercise programme in women with post-mastectomy lymphoedema (Ali et al., 2021).

Photobiomodulation is also described as an adjunct non-pharmacological intervention. Systematic reviews report potential beneficial effects on oedema reduction and pain relief; however, findings remain inconsistent, largely due to variability in treatment protocols and methodological limitations of the included studies (Baxter et al., 2017; Chen et al., 2019).

5.5. *Education*

Patient education constitutes an important component of physiotherapy management in BCRL, particularly within the maintenance phase of CDT. Systematic reviews indicate that patient education supports recognition of early symptoms, skin protection, appropriate physical activity and risk reduction practices, thereby enhancing patient engagement in self-care and supporting long-term management, although without a direct effect on limb volume reduction (Perdomo et al., 2023). Long-term management of BCRL relies on active patient participation, self-management and adherence to prescribed therapeutic recommendations (Shamoun & Ahmad, 2023). Education delivered by physiotherapists focuses on condition self-monitoring, appropriate use of compression therapy, continuation of therapeutic exercises, skin care and early recognition of signs of deterioration, which are essential for preventing complications and maintaining treatment effects (Torres-Lacomba et al., 2020; Wang et al., 2023).

6. Discussion

BCRL represents a complex clinical condition resulting from the interaction between anatomical characteristics of the lymphatic system, treatment-related damage, and individual patient-related risk factors (ISL, 2024; Pappalardo et al., 2021). Anatomical studies have demonstrated that lymphatic drainage of the breast and upper limb frequently converges within the axillary region, with lymph from both areas draining into the same axillary lymph nodes, including the sentinel lymph nodes (Cuadrado et al., 2018; Ma et al., 2019). This anatomical interconnection provides a clear explanation for the increased susceptibility following axillary surgical procedures performed as part of breast cancer treatment.

Although contemporary surgical approaches, such as sentinel lymph node biopsy, are less invasive than axillary lymph node dissection, disruption of lymphatic structures remains a relevant risk factor, particularly when combined with radiotherapy or other established contributors (Leong et al., 2022; Shen et al., 2022). Importantly, the pathophysiology of BCRL extends beyond simple mechanical obstruction. Damage to lymphatic vessels reduces lymph transport capacity, leading to the accumulation of protein-rich interstitial fluid, while chronic inflammation plays a central role in disease progression (ISL, 2024; Kataru et al., 2019). Persistent lymph stasis promotes immune activation, fibrosis, and adipose tissue deposition, resulting in irreversible tissue changes and reduced reversibility of lymphoedema (Kataru et al., 2019; Piller, 2020).

The progressive nature of BCRL highlights the importance of early detection, including identification of subclinical stages. Subjective symptoms such as limb heaviness or tightness often precede measurable volume changes, emphasising the clinical value of patient-reported outcomes in early recognition (Gursen et al., 2021).

Within this context, physiotherapy is consistently identified as a central component of conservative BCRL management. CDT remains the gold standard of care, as it integrates compression therapy, manual lymphatic drainage, therapeutic exercise, skin care, and patient education, addressing multiple pathophysiological mechanisms simultaneously. Evidence from a systematic review indicates that CDT leads to clinically meaningful reductions in limb volume and improvements in functional outcomes when applied in a structured and long-term manner (Shamoun & Ahmad, 2023).

Therapeutic exercise has gained increasing importance in contemporary physiotherapy practice. Current evidence demonstrates that progressive, individually tailored exercise programmes, including resistance training, do not exacerbate lymphoedema and contribute to improvements in muscle strength, functional capacity, and quality of life (Baumann et al., 2018; Hasenoehrl et al., 2020; Wang et al., 2023). Adjunct interventions such as kinesiotaping, hydrotherapy, and photobiomodulation may provide additional benefits; however, evidence regarding their effectiveness in reducing oedema remains inconsistent, supporting their role as complementary rather than primary interventions (Marotta et al., 2023; Yang et al., 2024).

Patient education represents a crucial component of long-term BCRL management. Although education interventions alone do not directly reduce limb volume, they support early symptom recognition, promote effective self-management, and contribute to the prevention of complications (Perdomo et al., 2023).

Finally, considerable interindividual heterogeneity exists in the onset, severity, and progression of BCRL, even among patients with similar oncological treatments (Hing et al., 2024; Pappalardo et al., 2021). This variability underscores the importance of individualised assessment and tailored physiotherapy interventions. Moreover, methodological heterogeneity across clinical studies highlights the need for standardised diagnostic criteria and long-term, high-quality research to optimise evidence-based management strategies further (Dylke, 2022; Yang et al., 2024).

7. Conclusions

BCRL is a common long-term complication associated with disruption of axillary lymphatic pathways and the anatomical interconnection between the lymphatic drainage of the breast and upper limb (Cuadrado et al., 2018; Ma et al., 2019). Evidence indicates that it is a chronic and progressive condition, for which physiotherapy, particularly CDT, represents the cornerstone of conservative management (Kataru et al., 2019; Shamoun & Ahmad, 2023). Effective long-term outcomes depend on the integration of anatomical knowledge, evidence-based physiotherapy and interdisciplinary collaboration, alongside active patient involvement (Hing et al., 2024; ISL, 2024).

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Ali KM, El Gammal ER, Eladl HM. Effect of Aqua Therapy Exercises on Postmastectomy Lymphedema: A Prospective Randomized Controlled Trial. Ann Rehabil Med. 2021; 45:131-140. DOI:10.5535/arm.20127
2. Armer JM, Stewart BR. Post-breast cancer lymphedema: incidence increases from 12 to 30 to 60 months. Lymphology. 2010; 43:118–127.
3. Baumann FT, Reike A, Reimer V, Schumann M, Hallek M, et al. Effects of physical exercise on breast cancer-related secondary lymphedema: a systematic review. Breast Cancer Res Treat.2018; 170:1–13. DOI:10.1007/s10549-018-4725-y
4. Baxter GD, Liu L, Petrich S, et al. Low level laser therapy (Photobiomodulation therapy) for breast cancer-related lymphedema: a systematic review. BMC Cancer. 2017; 17:833. DOI:10.1186/s12885-017-3852-x
5. Bowman C, Rockson SG. The Role of Inflammation in Lymphedema: A Narrative Review of Pathogenesis and Opportunities for Therapeutic Intervention. Int J Mol Sci. 2024; 25:3907. DOI:10.3390/ijms25073907
6. Cancer in Slovenia 2022. Ljubljana: Institute of Oncology Ljubljana, Epidemiology and Cancer Registry, Slovenian Cancer Registry, 2025. Available at: https://www.onko-i.si/rrs/rak-v-sloveniji. Accessed on: 25 May 2026.
7. Che Bakri NA, Kwasnicki RM, Khan N, et al. Impact of Axillary Lymph Node Dissection and Sentinel Lymph Node Biopsy on Upper Limb Morbidity in Breast Cancer Patients: A Systematic Review and Meta-Analysis. Ann Surg. 2023; 277:572-580. DOI:10.1097/SLA.0000000000005671
8. Chen HY, Tsai HH, Tam KW, Huang TW. Effects of photobiomodualtion therapy on breast cancer-related lymphoedema: A systematic review and meta-analysis of randomised controlled trials. Complement Ther Med. 2019; 47:102200. DOI:10.1016/j.ctim.2019.102200
9. Cuadrado GA, de Andrade MFC, Akamatsu FE, Jacomo AL. Lymph drainage of the upper limb and mammary region to the axilla: anatomical study in stillborns. Breast Cancer Res Treat. 2018; 169:251-256. DOI:10.1007/s10549-018-4686-1
10. 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; 14:500-515. DOI:10.1016/S1470-2045(13)70076-7
11. Dylke E. Measurement of breast cancer-related lymphoedema. Journal of Physiotherapy. 2022; 68:238–243. DOI:10.1016/j.jphys.2022.09.008
12. Eckert KM, Boughey JC, Piltin MA. Internal mammary lymphadenopathy in breast cancer: a narrative review and update. Translational Breast Cancer Research. 2024; 5. DOI:10.21037/tbcr-24-2
13. Grouthamel M. Lymphatic drainage of the breast. October 30, 2023. Available at: https://www.kenhub.com/en/library/anatomy/lymphatic-drainage-of-the-breast. Access on 25.05.2026
14. Gursen C, Dylke ES, Moloney N, et al. Self-reported signs and symptoms of secondary upper limb lymphoedema related to breast cancer treatment: Systematic review. Eur J Cancer Care (Engl). 2021; 30:e13440. DOI:10.1111/ecc.13440

15. 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; 28:3593-3603. DOI:10.1007/s00520-020-05521-x
16. Hayes SC, Johansson K, Stout NL, et al. Upper-body morbidity after breast cancer: incidence and evidence for evaluation, prevention, and management within a prospective surveillance model of care. Cancer. 2012; 118:2237-2249. DOI:10.1002/cncr.27467
17. Hing JX, Chua YN, Tan PT, et al. Defining breast cancer-related lymphedema (BCRL) prevalence and risk factors: A pragmatic approach to lymphedema surveillance. Ann Acad Med Singap. 2024; 53:80-89. DOI:10.47102/annals-acadmedsg.2023264
18. ISL. International Society of Lymphology. The diagnosis and treatment of peripheral lymphedema: 2023 Consensus Document of the International Society of Lymphology. Lymphology. 2024; 56:133-151. DOI: 10.2458/lymph.6372.
19. Janardhan HP, Wachter BT, Trivedi CM. Lymphatic System Development and Function. Curr Cardiol Rep. 2024; 26:1209-1219. DOI:10.1007/s11886-024-02120-8
20. Kataru RP, Wiser I, Baik JE, et al. Fibrosis and secondary lymphedema: chicken or egg?. Transl Res. 2019; 209:68-76. DOI:10.1016/j.trsl.2019.04.001
21. Leong SP, Pissas A, Scarato M, et al. The lymphatic system and sentinel lymph nodes: conduit for cancer metastasis. Clin Exp Metastasis. 2022; 39:139-157. DOI:10.1007/s10585-021-10123-w
22. Ma X, Wen S, Liu B, et al. Relationship between Upper Extremity Lymphatic Drainage and Sentinel Lymph Nodes in Patients with Breast Cancer. J Oncol. 2019; 2019:8637895. DOI:10.1155/2019/8637895
23. Marotta N, Lippi L, Ammendolia V, et al. Efficacy of kinesio taping on upper limb volume reduction in patients with breast cancer-related lymphedema: a systematic review of randomized controlled trials. Eur J Phys Rehabil Med. 2023; 59:237-247. DOI:10.23736/S1973-9087.23.07752-3
24. Matsumoto A, Ushio K, Kimura H, et al. Database study of risk factors for breast cancer-related lymphedema: a statistical analysis of 2359 cases over 10 years. Surg Today. 2025; 55:685-692. DOI:10.1007/s00595-024-02960-5
25. Oliver G, Kipnis J, Randolph GJ, Harvey NL. The Lymphatic Vasculature in the 21st Century: Novel Functional Roles in Homeostasis and Disease. Cell. 2020; 182:270-296. DOI:10.1016/j.cell.2020.06.039
26. Ozsoy-Unubol T, Sanal-Toprak C, Bahar-Ozdemir Y, Akyuz G. Efficacy of kinesio taping in early stage breast cancer associated lymphedema: A randomized single blinded study. Lymphology. 2019; 52:166-176.
27. Pappalardo M, Starnoni M, Franceschini G, Baccarani A, De Santis G. Breast Cancer-Related Lymphedema: Recent Updates on Diagnosis, Severity and Available Treatments. J Pers Med. 2021; 11:402. DOI:10.3390/jpm11050402
28. Perdomo M, Davies C, Levenhagen K, Ryans K, Gilchrist L. Patient education for breast cancer-related lymphedema: a systematic review. J Cancer Surviv. 2023; 17:384-398. DOI:10.1007/s11764-022-01262-4
29. Piller NB. Pathophysiology of Breast Cancer-Related Lymphoedema. Curr. Breast Cancer Rep. 2020; 12: 225–229. DOI:10.1007/s12609-020-00377-w
30. Shah C, Whitworth P, Valente S, et al. Bioimpedance spectroscopy for breast cancer-related lymphedema assessment: clinical practice guidelines. Breast Cancer Res Treat. 2023; 198:1-9. DOI:10.1007/s10549-022-06850-7
31. Shamoun S, Ahmad M. Complete Decongestive Therapy Effect on Breast Cancer Related to Lymphedema: A Systemic Review and Meta-Analysis of Randomized Controlled Trials. Asian Pac J Cancer Prev. 2023; 24:2225-2238. DOI:10.31557/APJCP.2023.24.7.2225
32. Shen A, Lu Q, Fu X, et al. Risk factors of unilateral breast cancer-related lymphedema: an updated systematic review and meta-analysis of 84 cohort studies. Support Care Cancer. 2022; 31:18. DOI:10.1007/s00520-022-07508-2
33. Silva CT, Silva CK, Casonatto J, Carrasco AC, McVeigh JG, Cardoso JR. Effects of aquatic exercises in woman who have undergone surgery after breast cancer: a systematic review with meta-analysis. Braz J Phys Ther. 2025; 29:101230. DOI:10.1016/j.bjpt.2025.101230
34. Sun F, Hall A, Tighe MP, et al. Perometry versus simulated circumferential tape measurement for the detection of breast cancer-related lymphedema. Breast Cancer Res Treat. 2018; 172:83-91. DOI:10.1007/s10549-018-4902-z
35. Swartz MA. The physiology of the lymphatic system. Adv Drug Deliv Rev. 2001; 50:3-20. DOI:10.1016/s0169-409x(01)00150-8
36. Torres-Lacomba M, Navarro-Brazález B, Prieto-Gómez V, Ferrandez JC, Bouchet JY, Romay-Barrero H. Effectiveness of four types of bandages and kinesio-tape for treating breast-cancer-related lymphoedema: a randomized, single-blind, clinical trial. Clin Rehabil. 2020; 34:1230-1241. DOI:10.1177/0269215520935943

37. Wang L, Shi YX, Wang TT, Chen KX, Shang SM. Breast cancer-related lymphoedema and resistance exercise: An evidence-based review of guidelines, consensus statements and systematic reviews. J Clin Nurs. 2023; 32:2208-2227. DOI:10.1111/jocn.16437
38. Yaman A, Borman P, İnanlı A, Kul F, Karahan S. The efficacy of different bandaging methods in patients with breast cancer-related lymphedema: A prospective, randomized study. Turk J Phys Med Rehabil. 2021; 67:155-166. DOI:10.5606/tftrd.2021.6287
39. Yang FA, Wu PJ, Su YT, Strong PC, Chu YC, Huang CC. Effect of Kinesiology Taping on Breast Cancer-Related Lymphedema: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Clin Breast Cancer. 2024; 24:541-551.e1. DOI:10.1016/j.clbc.2024.04.013
40. Zhang-Yin J, Mauel E, Talpe S. Update on Sentinel Lymph Node Methods and Pathology in Breast Cancer. Diagnostics (Basel). 2024; 14:252. DOI:10.3390/diagnostics14030252