



Efficacy of Complex Decongestive Therapy and Intermittent Pneumatic Compression in Patients With Breast Cancer-Related Lymphoedema: A Pragmatic Clinical Study

Dragana Bojinović-Rodić,^{1,2} Samra Pjanić,¹ Mirela Begić,³ Maja Vučković,^{1,2} Tamara Popović^{1,2}

Abstract

Background/Aim: Secondary arm lymphoedema is a common complication following breast cancer surgery. Complex decongestive therapy (CDT) represents the standard conservative treatment, but the incremental benefit of intermittent pneumatic compression (IPC) remains unclear. This study compared the efficacy of CDT alone with CDT combined with IPC on lymphoedema size, shoulder range of motion (ROM) and upper-limb function in patients with secondary arm lymphoedema following breast cancer treatment.

Methods: In this prospective, randomised, parallel, non-blinded study, 108 women with secondary arm lymphoedema were assigned to either the CDT (control) group or the CDT plus IPC (experimental) group. The CDT protocol included skin care, manual lymphatic drainage (MLD), short-stretch multilayer compression bandaging and therapist-guided exercises. The experimental group also received IPC for 30 minutes daily at 40 mm Hg. Treatments were administered once daily, five days per week, for three weeks. Outcome measures included arm circumference, shoulder ROM and the Disabilities of the Arm, Shoulder and Hand (DASH) scores assessed at baseline (T0), immediately post-treatment (T1) and three months post-treatment (T2). Statistical analyses included repeated-measures analysis of variance and analysis of covariance.

Results: Of the 108 participants, 102 completed the study (51 per group). No significant baseline differences were observed between groups. A significant main effect of time was found for all outcome measures ($p < 0.01$), indicating overall improvement during the study period. However, no significant group-by-time interactions were identified ($0.07 \leq p \leq 0.85$). There were no significant between-group differences in lymphoedema reduction, shoulder ROM or DASH scores at either T1 or T2.

Conclusions: The addition of IPC to standard CDT does not demonstrate additional benefits in managing secondary arm lymphoedema following breast cancer treatment.

Key words: Breast neoplasms; Lymphoedema; Complex decongestive therapy; Intermittent pneumatic compression devices; Compression bandages; Range of motion, articular.

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Introduction

Breast cancer-related lymphoedema (BCRL) is a chronic, progressive inflammatory disease of the interstitium, arising from impairment of the upper-limb lymphatic system, most commonly consequent to breast cancer surgery, radiotherapy, infection or trauma. The disruption of lymphatic transport leads to the accumulation of interstitial fluid, triggering chronic inflammation, progressive fibrosis, adipocyte hypertrophy and tissue remodelling, which further impair lymphatic function and contribute to disease progression.

The reported incidence of BCRL demonstrates considerable variability, ranging from 2 % to 77 %, depending on the type of axillary surgery and the oncological treatment modalities.¹⁻³ Following axillary lymph node dissection (ALND), BCRL affects approximately 25–35 % of patients.⁴ In contrast, sentinel lymph node biopsy (SLNB) is associated with a markedly lower incidence of 5.7 %, while omission of axillary surgery confers the lowest risk, with reported rates of 1.8 %.⁵ The accurate estimation of BCRL incidence remains challenging because of the unpredictable timing of its onset, which may occur immediately after breast cancer treatment or many years later, as well as variations among studies in diagnostic criteria, assessment methods and follow-up duration. The primary objectives of BCRL treatment are to reduce oedema, mobilise congested interstitial fluid, limit connective- and adipose-tissue proliferation, manage symptoms and minimise complications.

Complex decongestive therapy (CDT), comprising skin care, manual lymphatic drainage (MLD), compression therapy, exercise therapy and patient education, constitutes the foundation of conservative lymphoedema management.^{2, 6-8} In addition to reducing limb volume, CDT enhances symptoms, range of motion (ROM), limb function and overall quality of life (QoL).⁸⁻¹⁰ Intermittent pneumatic compression (IPC) is a mechanical form of compression therapy that applies sequential pressure through air chambers, creating a wave-like effect in a distal-to-proximal direction, thereby simulating the physiological function of the muscle pump and promoting lymphatic and venous drainage.

According to the recommendations of many authors and guidelines, IPC may be employed

as an adjunctive modality to CDT during either the intensive or maintenance phase.^{2, 7, 11-14} Nevertheless, the evidence regarding its effectiveness as an adjunct to CDT remains inconsistent.^{15, 16}

Although some randomised controlled trials have indicated that the addition of IPC to CDT may result in greater reductions in lymphoedema,^{17, 18} the findings of other studies have not demonstrated a significant additional benefit compared with CDT alone.¹⁹⁻²¹

The objective of this study was to compare the efficacy of CDT alone with CDT combined with IPC on lymphoedema size ROM and upper-limb function in patients with secondary arm lymphoedema following breast cancer treatment.

Methods

This prospective, randomised, parallel, non-blinded study was conducted at the Institute of Physical Medicine, Rehabilitation and Orthopaedic Surgery “Dr Miroslav Zotović” in Banja Luka and included patients with secondary arm lymphoedema following breast cancer surgery. Ethical approval was obtained from the institutional Ethics Review Committee.

The inclusion criteria for the study were: unilateral axillary dissection; clinically confirmed lymphoedema (defined as a difference in circumference of more than 2 cm between the affected and unaffected arm at least at one measurement site), more than three months since breast cancer surgery and radiotherapy and patient-signed informed consent, provided with prior knowledge of the trial's purpose.

The exclusion criteria included metastatic breast disease, acute or recent cellulitis (within two weeks of resolution), uncontrolled hypertension, heart failure, deep venous thrombosis or anticoagulant therapy, pre-existing neurological, orthopaedic, or rheumatic disorders of the upper limb, treated psychiatric disorders, liver cirrhosis and nephrotic syndrome.

Intervention

Patients were randomly assigned to either the CDT (control) group or the CDT + IPC (experimental) group. The CDT protocol comprised skin care,

MLD according to the Vodder technique, short-stretch multilayer compression bandaging (CB) and therapist-guided exercises. Exercises were performed under compression bandaging. The programme included diaphragmatic breathing exercises, remedial exercises, stretching exercises and resistance exercises for the affected arm.

In addition, the experimental group received IPC for 30 minutes per day at a pressure of 40 mm Hg using a sequential compression mode. IPC was applied after MLD and before CB using the Ekopress-8 device (*Electronic Design Medical*), equipped with six arm chambers and two trunk chambers. The trunk chambers were not utilised in the present study.

Both groups used an identical conventional short-stretch multilayer bandaging system for arm lymphoedema (*Rosidal® K Lymphset, Lohmann & Rauscher*, Vienna, Austria). Patients were instructed to wear the bandages as long as possible, ie until the next treatment session. Bandage adherence was monitored using a "bandage log," in which patients recorded daily application and removal times, allowing calculation of total bandage-wearing duration.

Treatments were administered once daily, five days per week, for three weeks. After completion of the treatment course, participants were instructed to continue skin care, use of compression sleeves and exercises independently for three months.

Outcomes

Arm circumference, ROM and overall upper limb function, assessed using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, were measured at baseline (T0), immediately post-treatment (T1) and at three months post-treatment (T2).

Lymphoedema was assessed by measuring arm circumference at seven symmetrical levels: metacarpophalangeal joints, radial styloid process, 10, 20, 30 and 40 cm from the radial styloid process and over the olecranon, on both the ipsilateral (affected) and contralateral (unaffected) arms.

Lymphoedema size was expressed as the ratio of the total circumference of the affected to the unaffected arm, calculated using the following formula:

$$\text{Lymphoedema size (\%)} = \left[\frac{\text{Total circumference of affected arm} - \text{Total circumference of unaffected arm}}{\text{Total circumference of unaffected arm}} \right] \times 100.$$
 A value of 0 % indicates equal total circumferences of both arms.

The percentage of lymphedema reduction was calculated using the formula:

$$\text{Reduction (\%)} = \left[\frac{\text{total circumference of affected arm before treatment} - \text{total circumference of affected arm after treatment}}{\text{total circumference of affected arm before treatment} - \text{total circumference of unaffected arm}} \right] \times 100.$$
 A value of 100 % indicates equal total circumferences of both arms.¹⁵

Shoulder ROM in the affected arm was measured using a goniometer. The following movements were assessed: flexion (FL), extension (EXT), abduction (ABD), internal rotation (IR) and external rotation (ER). In addition to the objective measurements described above, upper-limb function was assessed using the region-specific, patient-reported DASH questionnaire. The DASH is a valid and user-friendly tool for evaluating upper-limb disability and has been validated in women who are breast cancer survivors, consistently demonstrating large effect sizes for construct validity and responsiveness.^{22, 23}

Statistical analysis

Within descriptive statistics, numerical variables were presented using measures of central tendency (mean, median) and measures of variability (standard deviation-SD, range and interquartile range). Categorical variables were presented as frequencies and percentages.

Comparisons of numerical variables between two groups were conducted using Student's t-test or, for sample sizes smaller than 30, the non-parametric Mann-Whitney U test. Differences in frequencies of categorical variables were analysed using the Chi-square (χ^2) test with Yates's continuity correction, or Fisher's exact test where appropriate. To assess the statistical significance of differences between two therapeutic protocols, a repeated-measures analysis of variance (rANOVA) was used. When the assumption of sphericity was violated, the Huynh-Feldt correction was applied. For parameters in which a statistically significant difference between groups was found before therapy, analysis of covariance (ANCOVA) was used, with baseline values included as covariates.

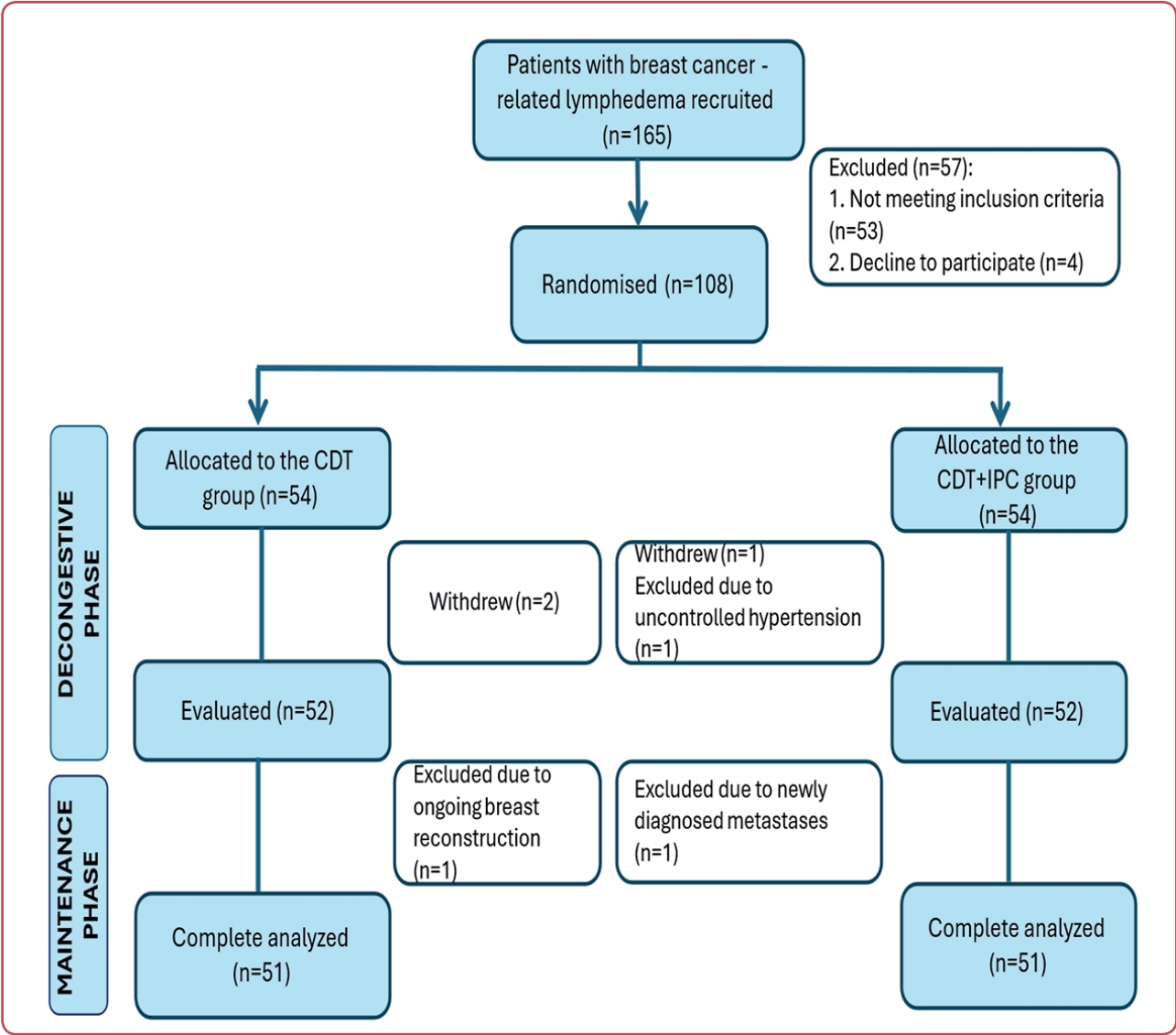


Figure 1: Flow diagram of participants through the study

All analyses were performed using SPSS software (version 21.0) and a p-value of < 0.05 was considered statistically significant.

The flow chart of participant progression through the study is shown in Figure 1.

Results

The groups were homogeneous with respect to most demographic and clinical characteristics, with no statistically significant differences observed between them (Table 1).

During the initial phase of treatment, the mean duration of bandage wear was 212.5 ± 97.8 hours in the CDT group and 181.7 ± 57.8 hours in the CDT+IPC group. Patients in the CDT group wore bandages for a significantly longer duration than those in the CDT+IPC group (Figure 2).

Comparative efficacy of two therapeutic protocols on lymphoedema size

Repeated measures analysis of variance (rANOVA) was used to assess the effects of two therapeutic protocols (CDT and CDT + IPC) on changes in lymphoedema size across three time points: baseline (T0), immediately post-treatment (T1) and three months post-treatment (T2). The analysis demonstrated a statistically significant effect of time on lymphoedema size ($F = 158.73$; $df = 1.79$; $p < 0.001$). The Time $\times$ Group

Table 1: Baseline patient characteristics

Characteristic	CDT group	CDT+IPC group	p-value
Patient age (years), mean (SD)	58.1 ± 8.0	55.4 ± 8.8	¹ 0.112
Body mass index, mean (SD)	28.4 ± 4.3	28.8 ± 4.9	¹ 0.636
Time from surgery (months), mean (SD)	53.4 ± 50.0	61.3 ± 42.1	¹ 0.389
Type of breast surgery, n (%)			
Radical mastectomy	30 (58.8)	34 (66.7)	² 0.539
Breast-conserving surgery	21 (41.2)	17 (33.3)	
Side of surgery (lymphoedema), n (%)			
Right	28 (54.9)	35 (68.6)	² 0.154
Left	23 (45.1)	16 (31.4)	
Histopathological type of breast carcinoma			
Invasive ductal carcinoma	37 (72.5)	38 (74.5)	³ 1.000
Invasive lobular carcinoma	3 (5.9)	7 (13.7)	
Other types of carcinomas	11 (21.6)	6 (22.8)	
Number of lymph nodes removed, mean (SD)	14.2 ± 6.6	14.2 ± 5.9	¹ 0.975
Number of lymph nodes involved, mean (SD)	2.8 ± 6.1	3.0 ± 5.6	¹ 0.853
Oncological treatment, n (%)			
Chemotherapy	37 (72.5)	41 (80.4)	³ 0.480
Radiotherapy	38 (74.5)	37 (72.5)	³ 1.000
Endocrine therapy	37 (72.5)	33 (64.7)	³ 0.522
Lymphoedema duration (months), mean (SD)	36.5 ± 43.9	43.3 ± 38.2	¹ 0.406
Time from surgery to onset (months), mean (SD)	17.0 ± 22.9	19.6 ± 28.2	¹ 0.607
Previous erysipelas, n (%)			
Yes	7 (13.7)	5 (9.8)	² 0.539
No	44 (86.3)	46 (90.2)	
Affected arm, n (%)			
Dominant	28 (54.9)	35 (68.6)	² 0.154
Non-dominant	23 (45.1)	16 (31.4)	
Pain and other arm symptoms			
Yes	44 (86.3)	48 (94.1)	² 0.318
No	7 (13.7)	3 (5.9)	
Visual Analogue Scale (VAS), mean (SD)	4.07 ± 3.19	3.57 ± 2.46	¹ 0.377
Size of lymphoedema (%), mean (SD)	6.99 ± 5.36	6.53 ± 3.83	¹ 0.616
DASH, mean (SD)	38.2 ± 18.9	31.4 ± 16.4	¹ 0.056
Comorbidity (treated with medication), n (%)			
Hypertension	23 (45.1)	20 (39.2)	³ 0.689
Heart disease	9 (17.6)	5 (7.8)	³ 0.389
Thyroid disorders	12 (23.5)	11 (21.6)	³ 1.000
Diabetes mellitus	4 (7.8)	4 (7.8)	³ 1.000
Venous insufficiency of the lower limbs	5 (9.8)	4 (7.8)	³ 1.000
Other	5 (9.8)	2 (3.9)	³ 0.436

¹Student's t-test, ²Chi-square test, ³Fisher's exact test; CDT: Complex decongestive therapy; IPC: Intermittent pneumatic compression; DASH: Disabilities of the Arm, Shoulder and Hand questionnaire;

interactions were not statistically significant ($F = 2.20$; $df = 1.79$; $p = 0.12$), indicating similar changes in lymphoedema size in both treatment groups (Figure 3).

Comparative efficacy of two therapeutic protocols on the shoulder ROM

Significant improvements in shoulder flexion, abduction and internal rotation were observed in both groups immediately post-treatment and at

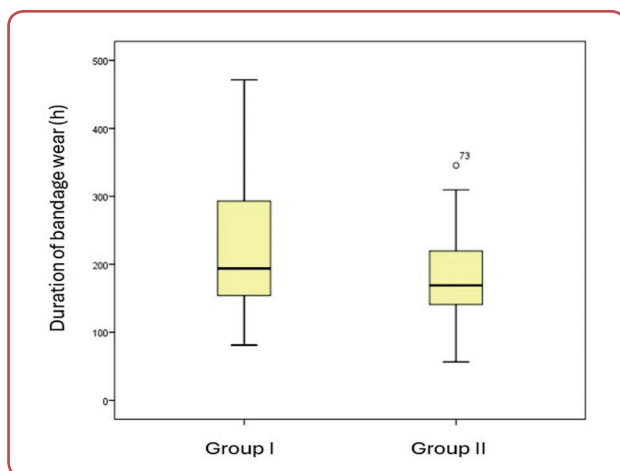


Figure 2: Distribution of patients according to bandage-wearing duration

I: Control group (CDT): Complex decongestive therapy group; II: Experimental group: CDT + IPC: Complex decongestive therapy + intermittent pneumatic compression group;

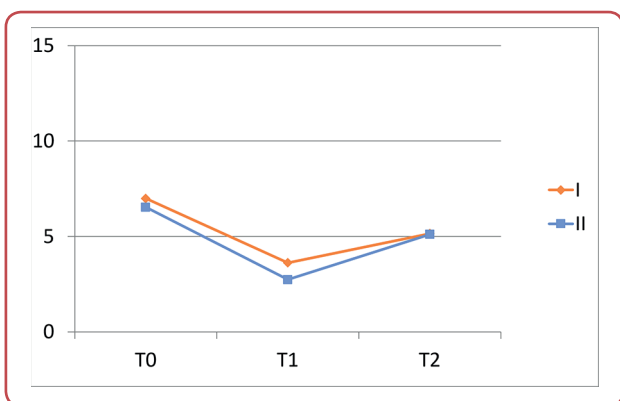


Figure 3: Changes in lymphoedema size during the observation period

I: Control group (CDT): Complex decongestive therapy group; II: Experimental group: CDT + IPC: Complex decongestive therapy + intermittent pneumatic compression group; T0: Baseline, T1: post-treatment, T2: three-month follow-up;

follow-up, whereas changes in external rotation and extension were not statistically significant (Table 2, Figure 4-8). The Time $\times$ Group interaction for all shoulder ROM measures was not significant, indicating a similar pattern of change in both groups (FL: $F = 0.37$; $df = 1.67$; $p = 0.65$; ABD: $F = 2.99$; $df = 1.56$; $p = 0.07$; IR: $F = 0.11$; $df = 1.63$; $p = 0.85$; ER: $F = 2.01$; $df = 1.33$; $p = 0.15$; EXT: $F = 0.41$; $df = 1.78$; $p = 0.64$).

Comparative efficacy of two therapeutic protocols on DASH

Repeated-measures ANOVA showed a statistically significant effect of time on changes in the DASH score ($F = 113.15$; $df = 1.73$; $p < 0.001$). The Time $\times$ Group interaction was not statistically significant

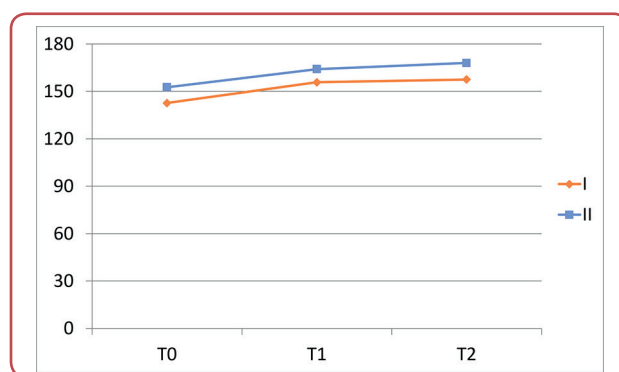


Figure 4: Changes in shoulder flexion (FL) during the observation period

I: Control group (CDT): Complex decongestive therapy group; II: Experimental group: CDT + IPC: Complex decongestive therapy + intermittent pneumatic compression group; T0: Baseline, T1: post-treatment, T2: three-month follow-up;

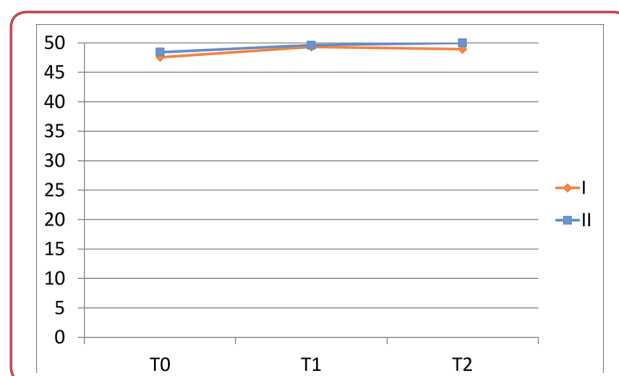


Figure 5: Changes in shoulder extension (EXT) during the observation period

I: Control group (CDT): Complex decongestive therapy group; II: Experimental group: CDT + IPC: Complex decongestive therapy + intermittent pneumatic compression group; T0: Baseline, T1: post-treatment, T2: three-month follow-up;

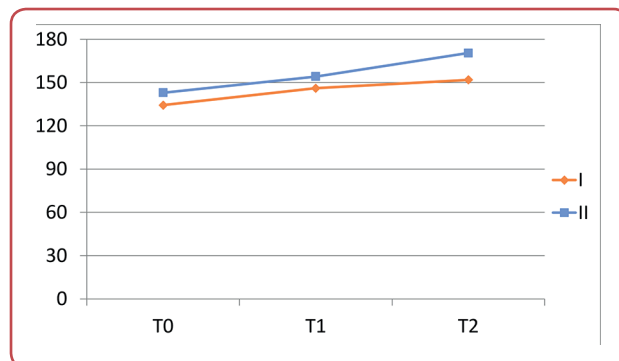


Figure 6: Changes in shoulder abduction (ABD) during the observation period

I: Control group (CDT): Complex decongestive therapy group; II: Experimental group: CDT + IPC: Complex decongestive therapy + intermittent pneumatic compression group; T0: Baseline, T1: post-treatment, T2: three-month follow-up;

($F = 0.36$; $df = 1.73$; $p = 0.67$), indicating that changes in DASH score did not differ statistically between groups (Figure 9).

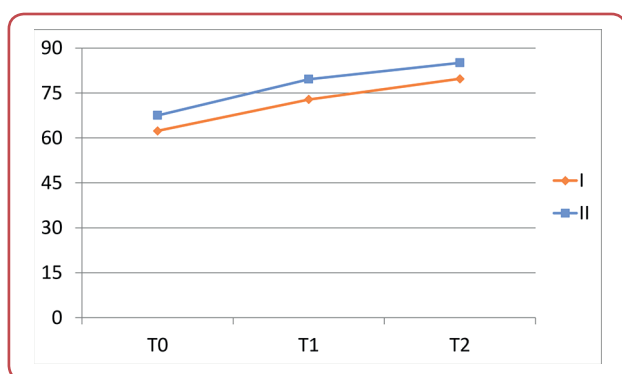


Figure 7: Changes in shoulder internal rotation (IR) during the observation period

I: Control group (CDT): Complex decongestive therapy group; II: Experimental group: CDT + IPC: Complex decongestive therapy + intermittent pneumatic compression group; T0: Baseline, T1: post-treatment, T2: three-month follow-up;

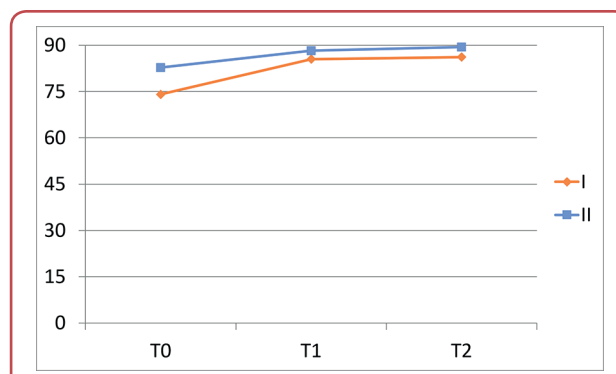


Figure 8: Changes in shoulder external rotation (ER) during the observation period

I: Control group (CDT): Complex decongestive therapy group; II: Experimental group: CDT + IPC: Complex decongestive therapy + intermittent pneumatic compression group; T0: Baseline, T1: post-treatment, T2: three-month follow-up;

Table 2: Baseline, post-treatment and three-month follow-up ROM in both groups

Outcome variables	T0		T1		T2		*p-value	
	CDT	CDT+IPC	CDT	CDT+IPC	CDT	CDT+IPC	T0-T1	T1-T2
Shoulder flexion	142.6 ± 24.0	152.6 ± 23.5	155.8 ± 19.0	164.1 ± 16.5	157.6 ± 20.8	167.9 ± 15.6	< 0.001	< 0.001
Shoulder abduction	134.3 ± 36.9	142.9 ± 35.5	146.1 ± 29.9	162.2 ± 24.6	151.9 ± 31.7	170.5 ± 20.2	< 0.001	< 0.001
Shoulder internal rotation	62.3 ± 28.2	67.6 ± 23.1	72.8 ± 22.1	79.6 ± 16.0	79.7 ± 20.3	85.1 ± 11.7	< 0.001	< 0.001
Shoulder external rotation	74.1 ± 22.9	82.7 ± 16.4	85.5 ± 9.7	88.2 ± 6.47	86.2 ± 12.8	89.4 ± 3.1	< 0.001	0.370
Shoulder extension	47.6 ± 6.1	48.4 ± 4.6	49.3 ± 3.2	49.6 ± 1.9	48.9 ± 4.3	50.0 ± 0.0	< 0.001	1.000

Repeated-measures ANOVA; CDT: Complex decongestive therapy; IPC: Intermittent pneumatic compression; T0: Baseline, T1: post-treatment, T2: three-month follow-up;

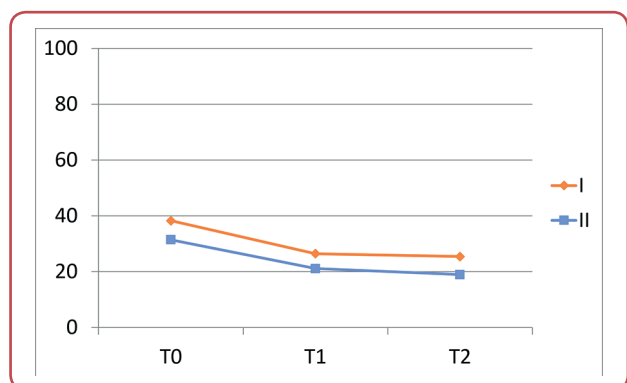


Figure 9: Changes in Disabilities of the Arm, Shoulder and Hand (DASH) scores during the observation period

I: Control group (CDT): Complex decongestive therapy group; II: Experimental group: CDT + IPC: Complex decongestive therapy + intermittent pneumatic compression group; T0: Baseline, T1: post-treatment, T2: three-month follow-up;

Discussion

The results of our study demonstrated that, following the intensive phase of treatment, both therapeutic protocols (CDT and CDT combined with IPC) effectively reduced lymphoedema, with no significant differences observed between the groups. At the 3-month follow-up, lymphoedema volume had significantly increased in both groups compared with post-treatment measurements; however, it remained lower than the baseline value. A review of the literature identified several randomised studies evaluating the efficacy of IPC in the management of lymphoedema.^{17-21, 24-26}

Szuba et al compared CDT alone versus CDT combined with IPC during both the intensive and maintenance phases, showing that both protocols were effective. However, IPC produced greater volume reduction shortly after the intensive phase, though differences diminished by 30 days and outperformed self-administered manual lymphatic drainage and compression wrapping during maintenance.¹⁷ Although IPC did not

provide additional benefit in presented study, both groups achieved greater lymphoedema reductions than those reported by Szuba et al after the intensive phase and at follow-up.¹⁷ This may reflect the longer treatment duration and stricter inclusion criteria in our study, as Szuba et al's participants were older and had larger baseline oedema.¹⁷

Szolonky et al reported that both CDT alone and CDT + IPC significantly reduced lymphoedema, with consistently greater volume reduction in the IPC group.¹⁸ The study had a small sample and applied slightly higher pressures (50 mm Hg) than in our study, which may have influenced the outcomes.

Haghihat et al found CDT more effective than CDT + IPC after the intensive phase, although no significant differences were observed during the maintenance phase.¹⁹ Their study was similar to ours in design, sample size, IPC parameters and follow-up; however, MLD in their CDT group lasted twice as long, which may explain the superior initial response. Additionally, the number of treatment days (10–15) was unclear, whereas in presented study, both groups received identical CDT protocols and treatment duration, differing only in IPC application.

Another study with a similar design and findings to ours was the controlled clinical trial by Uzkeser et al.²⁰

In a randomised study, Sanal-Toprak et al compared MLD and IPC within CDT for BCRL. Both were effective after 15 sessions over five weeks, but at the three-month follow-up, arm volume increased significantly only in the MLD group, suggesting that IPC may serve as a substitute for MLD.²⁴ IPC may be an effective substitute for MLD during the maintenance phase of CDT, although its benefits appear limited to a short timeframe.²⁵ Tastaban et al showed that adding IPC to CDT did not significantly improve its efficacy, but provided greater relief of heaviness and tightness in patients with pitting oedema.²¹

Diab et al demonstrated that CDT combined with IPC and kinesiology taping produced greater lymphoedema reduction than CDT alone; however, the study included only 15 patients per group and used higher IPC pressures (60 mm Hg) than in presented study.²⁶ A recent systematic review and meta-analysis found no significant

difference between decongestive lymphatic therapy (DLT) + IPC and DLT alone for post-breast cancer upper limb lymphoedema in terms of volume reduction, pain, or heaviness.²⁷

Another systematic review and meta-analysis of clinical studies reported that IPC combined with CDT significantly reduced limb volume within four weeks post-treatment, although effects diminish by eight weeks after therapy cessation. Patients' pain perception changed minimally, regardless of IPC use.²⁸ Beyond lymphoedema reduction, some studies have evaluated therapeutic effectiveness in terms of pain and symptom relief¹⁸⁻²¹ and improvements in ROM.^{17, 24, 26}

No difference between the groups was observed in the ROM over time. Both groups showed significant post-treatment improvements in all ROM measures, which persisted at follow-up for flexion (FL), abduction (ABD) and internal rotation (IR). External rotation (ER) and extension (EXT) at follow-up did not reach statistical significance, although patients in both groups demonstrated near-full ER, slightly higher in the CDT + IPC group (86.2 vs 89.4, respectively). EXT decreased at follow-up in the CDT group but reached a maximum of 50 in the CDT + IPC group; these differences were not statistically significant. Similar findings were reported by Szuba et al with all ROM increasing following both the initial and maintenance phases, regardless of group allocation.¹⁷

Sanal-Tropic et al reported significant improvements in shoulder FL and ABD both immediately post-treatment and at follow-up compared with baseline values.²⁴ Diab et al reported significant post-treatment improvements in shoulder ROM in both groups, with greater gains observed in the IPC and kinesiology taping group.²⁶ A systematic review and meta-analysis reported that adding IPC to CDT produced small but significant improvements in shoulder ABD, EXT, FL and ER compared with CDT alone.²⁸ In contrast, another review found benefits only in ER, with no significant effects on ABD or FL.²⁷

Presented results showed no significant differences in upper extremity function, as measured by the DASH score, between CDT alone and CDT combined with IPC; both protocols effectively improved upper limb function immediately post-treatment and at follow-up. Similar findings were reported by Tastaban

et al, who used the shortened Quick DASH questionnaire.²¹ In a randomised crossover trial comparing CPT + IPC with kinesiology taping alone for BCRL, upper limb function, assessed by the DASH questionnaire, improved more in the kinesiology taping group.²⁹

Across the included studies, IPC pressures ranged from 30 to 60 mm Hg, with treatment sessions lasting 30–60 minutes. No consensus exists regarding optimal pressure, duration, or application frequency for upper limb lymphoedema. While higher pressures have been more widely studied and recommended for lower limb lymphoedema, evidence for optimal pressure in the upper limb remains limited.^{11, 30} Low- to moderate-quality evidence supports the use of multicell, sequential IPC at 30–60 mm Hg for 45–60 minutes in managing upper limb lymphoedema.³¹ The 2025 systematic review and meta-analysis indicated that IPC provided preventive benefits for BCRL when applied early post-surgery, whereas its therapeutic efficacy in established lymphoedema remains inconsistent and generally limited to pressures ≤ 40 mm Hg and treatment durations exceeding two weeks.³²

None of the previous studies comparing CDT alone versus CDT combined with IPC measured bandage wear duration during the intensive phase, as was done in our study. Patients in the CDT group wore compressive bandages for longer period. Compression therapy is considered the most important component of CDT, both during the intensive and maintenance phases.³³ Unequal exposure to compression therapy represents a potential factor that may have influenced treatment outcomes and the assessment of the additional effect of IPC.

Limitations of the study

This prospective, randomised study was conducted at a specialised lymphoedema centre with a relatively large, homogeneous patient sample. A standardised protocol was applied and MLD was performed by certified physiotherapists under the researcher's supervision. Limitations included self-reported adherence to CDT during the maintenance phase, no IPC application in this phase and a short follow-up. As CDT participants wore bandages longer during the intensive phase, it remained uncertain whether lower adherence in the CDT + IPC group affected the therapeutic response. Future studies should stratify patients by adherence and

investigate its impact during both intensive and maintenance phases.

Conclusion

The addition of IPC to standard CDT does not result in greater reductions in BCRL compared with CDT alone, nor does it demonstrate superior improvements in ROM or upper-limb function. Reliable assessment of IPC efficacy is limited by variations in treatment protocols and the use of different devices, emphasising the need for further multicentre randomised controlled trials with standardised IPC protocols to confirm clinical effectiveness and strengthen the evidence base.

Ethics

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the Institute for Physical Medicine, Rehabilitation and Orthopaedic Surgery "Dr Miroslav Zotovic" (protocol code 1981/14, 7 April 2014). Written informed consent was obtained from all participants involved in the study.

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Conflicts of interest

The authors declare that there is no conflict of interest.

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Data access

The data that support the findings of this study are available from the corresponding author upon reasonable individual request.

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Methodology: DBR, SP, MB, MV, TP

Validation: DBR, SP, MB, MV, TP

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References

- McEvoy MP, Gomberawalla A, Smith M, Boccardo FM, Holmes D, Djohan R, et al. The prevention and treatment of breast cancer-related lymphedema: a review. *Front Oncol.* 2022;12:1062472. doi: 10.3389/fonc.2022.1062472.
- Donahue PMC, MacKenzie A, Filipovic A, Koelmeyer L. Advances in the prevention and treatment of breast cancer-related lymphedema. *Breast Cancer Res Treat.* 2023;200:1-14. doi: 10.1007/s10549-023-06947-7.
- Chaput G, Ibrahim M, Towers A. Cancer-related lymphedema: clinical pearls for providers. *Curr Oncol.* 2020;27(6):336-40. doi: 10.3747/co.27.7225.
- Coriddi M, Dayan J, Bloomfield E, McGrath L, Diwan R, Monge J, et al. Efficacy of immediate lymphatic reconstruction to decrease incidence of breast cancer-related lymphedema: preliminary results of a randomized controlled trial. *Ann Surg.* 2023;278(4):630-7. doi: 10.1097/SLA.0000000000005952.
- Reimer T, Stachs A, Veselinovic K, Kühn T, Heil J, Polata S, et al. Axillary surgery in breast cancer: primary results of the INSEMA trial. *N Engl J Med.* 2025;392(11):1051-64. doi: 10.1056/NEJMoa2412063.
- Gilchrist L, Levenhagen K, Davies CK, Koehler L. Effectiveness of complete decongestive therapy for upper extremity breast cancer-related lymphedema: a review of systematic reviews. *Med Oncol.* 2024;41(11):297. doi: 10.1007/s12032-024-02421-6.
- Bergmann A, Baiocchi JMT, de Andrade MFC. Conservative treatment of lymphedema: the state of the art. *J Vasc Bras.* 2021;20:e20200091. doi: 10.1590/1677-5449.200091.
- Dzupina A, Yaluri N, Singh J, Jankajova M. Predictors of the efficacy of lymphedema decongestive therapy. *Medicina (Kaunas).* 2025;61(2):231. doi: 10.3390/medicina61020231.
- Kuzmanović M, Mustur D. Effects of 4-week complex decongestive therapy in the management of breast cancer-related arm lymphedema in Montenegrin women post-mastectomy and chemo/radiotherapy. *Healthcare (Basel).* 2025;13(20):2596. doi: 10.3390/healthcare13202596.
- Shamoun S, Ahmad M. Complete decongestive therapy effect on breast cancer-related lymphedema: a systematic review and meta-analysis of randomized controlled trials. *Asian Pac J Cancer Prev.* 2023;24(7):2225-38. doi: 10.31557/APJCP.2023.24.7.2225.
- Pandy SK, Ozmen BB, Morkuzu S, Xiong Y, Kemp E, Chen WF. Current role of pneumatic compression therapy in lymphedema care: a scoping review of persistent debates and new applications. *Lymphology.* 2024;57(3):142-56. PMID: 39874051.
- Földi E, Albert US, Helmbrecht S, Ludwig M, Miller A, Oberlin M, et al. Working Group 4: conservative therapy. S2k guideline "Diagnostics and therapy of lymphoedema" (registry no. 058-001 of the Association of the Scientific Medical Societies in Germany—Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften e.V., AWMF), May 2017.
- Executive Committee of the International Society of Lymphology. The diagnosis and treatment of peripheral lymphedema: 2023 consensus document of the International Society of Lymphology. *Lymphology.* 2023;56(4):133-51. PMID: 39207406.
- Davies C, Levenhagen K, Ryans K, Perdomo M, Gilchrist L. Interventions for breast cancer-related lymphedema: clinical practice guideline from the Academy of Oncologic Physical Therapy of APTA. *Phys Ther.* 2020;100(7):1163-79. doi: 10.1093/ptj/pzaa087.
- Shao Y, Qi K, Zhou QH, Zhong DS. Intermittent pneumatic compression pump for breast cancer-related lymphedema: a systematic review and meta-analysis of randomized controlled trials. *Oncol Res Treat.* 2014;37(4):170-4. doi: 10.1159/000360786.
- Hamner JB, Fleming MD. Lymphedema therapy reduces the volume of edema and pain in patients with breast cancer. *Ann Surg Oncol.* 2007;14(6):1904-8. doi: 10.1245/s10434-006-9332-1.
- Szuba A, Achalu R, Rockson SG. Decongestive lymphatic therapy for patients with breast carcinoma-associated lymphedema: a randomized, prospective study of a role for adjunctive intermittent pneumatic compression. *Cancer.* 2002;95(11):2260-7. doi: 10.1002/cncr.10976.

18. Szolnoky G, Lakatos B, Keskeny T, Varga E, Varga M, Dobozsy A, et al. Intermittent pneumatic compression acts synergistically with manual lymphatic drainage in complex decongestive physiotherapy for breast cancer treatment-related lymphedema. *Lymphology*. 2009;42(4):188-94. PMID:20218087.
19. Haghighat S, Lotfi-Tokaldany M, Yunesian M, Akbari ME, Nazemi F, Weiss J. Comparing two treatment methods for post-mastectomy lymphedema: complex decongestive therapy alone and in combination with intermittent pneumatic compression. *Lymphology*. 2010;43(1):25-33. PMID: 20552817.
20. Uzkeser H, Karatay S, Erdemci B, Koc M, Senel K. Efficacy of manual lymphatic drainage and intermittent pneumatic compression pump use in the treatment of lymphedema after mastectomy: a randomized controlled trial. *Breast Cancer*. 2015;22(3):300-307. doi: 10.1007/s12282-013-0481-3.
21. Tastaban E, Soyder A, Aydin E, Sendur OF, Turan Y, Ture M, et al. Role of intermittent pneumatic compression in the treatment of breast cancer-related lymphoedema: a randomized controlled trial. *Clin Rehabil*. 2020;34(2):220-8. doi: 10.1177/0269215519888792.
22. Hudak PL, Amadio PC, Bombardier C; Upper Extremity Collaborative Group. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. *Am J Ind Med*. 1996;29(6):602-8. doi: 10.1002/(SICI)1097-0274(199606)29:6<602::AID-AJIM4>3.0.CO;2-L.
23. Harrington S, Michener LA, Kendig T, Miale S, George SZ. Patient-reported upper extremity outcome measures used in breast cancer survivors: a systematic review. *Arch Phys Med Rehabil*. 2014;95(1):153-162. doi: 10.1016/j.apmr.2013.07.022.
24. Sanal-Toprak C, Ozsoy-Unubol T, Bahar Ozdemir Y, Akyuz G. The efficacy of intermittent pneumatic compression as a substitute for manual lymphatic drainage in complete decongestive therapy in the treatment of breast cancer-related lymphoedema. *Lymphology*. 2019;52(2):82-91. PMID:31525829.
25. Mendoza E, Amsler F. Effectiveness of manual lymphatic drainage and intermittent pneumatic compression in lymphedema maintenance therapy. *Vasa*. 2023;52(6):423-31. doi: 10.1024/0301-1526/a001090.
26. Diab HA, Asham HN, Aboelnour NH, Alagizy HA. Effect of intermittent pneumatic compression in combination with kinesiotape on post-mastectomy lymphedema. *Egypt J Hosp Med*. 2021;85(1):2794-9. doi: 10.21608/ejhm.2021.189943.
27. Yao M, Peng P, Ding X, Sun Q, Chen L. Comparison of intermittent pneumatic compression pump as adjunct to decongestive lymphatic therapy against decongestive therapy alone for upper limb lymphedema after breast cancer surgery: a systematic review and meta-analysis. *Breast Care (Basel)*. 2024;19(3):155-64. doi: 10.1159/000538940.
28. Hou S, Li Y, Lu W, Zhang X, Luo H, Qiu J, et al. Efficacy of intermittent pneumatic compression on breast cancer-related upper limb lymphedema: a systematic review and meta-analysis in clinical studies. *Gland Surg*. 2024;13(8):1358-69. doi: 10.21037/gs-24-123.
29. Pajero Otero V, García Delgado E, Martín Cortijo C, Rodríguez Ramos ML, De Carlos Iriarte E, Gil García A, et al. Intensive complex physical therapy combined with intermittent pneumatic compression versus kinesio taping for treating breast cancer-related lymphedema of the upper limb: a randomized crossover clinical trial. *Eur J Cancer Care (Engl)*. 2022;31(5):e13625. doi: 10.1111/ecc.13625.
30. Zaleska MT, Olszewski WL, Durlik M, Kaczmarek MK, Freidenrich B. Tonometry of deep tissues for setting effective compression pressures in lymphedema of limbs. *Lymphat Res Biol*. 2018;16(2):193-200. doi: 10.1089/lrb.2016.0069.
31. Phillips JJ, Gordon SJ. Intermittent pneumatic compression dosage for adults and children with lymphedema: a systematic review. *Lymphat Res Biol*. 2019;17(1):2-18. doi: 10.1089/lrb.2018.0034.
32. Su L, Huang H, Tong Y, Dong L, Gu C, Zhuang S, et al. Intermittent pneumatic compression devices for the prevention and treatment of breast cancer-related lymphedema: a systematic review and meta-analysis. *Support Care Cancer*. 2025;33(12):1113. doi: 10.1007/s00520-025-10159-8.
33. Hirsch T, Arns H, Schleinitz J, Fiedler HW. An innovative flat-knit compression garment for lymphoedema patients led to better outcomes: a multicentre study. *J Wound Care*. 2024;33(4):220-8. doi: 10.12968/jowc.2024.33.4.220.