Research Article

Different Dosages of Extracorporeal Shock Wave Therapy in Post Mastectomy Lymphedema

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Abstract

Background: Secondary edema of the upper limbs is a debilitating and sometimes fatal condition that impacts the quality of life of patients. The purpose of this study is to determine the optimal number of impulses of extracorporeal shock wave therapy (ESWT) to reduce lymphedema in secondary upper extremity lymphedema, as well as its pain levels, QoL, and skin thickness relative to fibrosis.

Methods: Forty-five female patients, ranging in age from 35 to 65, were evaluated for upper extremity lymphedema (Foldi classification: stage 2, 3). Each of the three groups consisted of fifteen patienta.

Material and Methods: With a total of fifteen participants, group A underwent full decongestive therapy (CDT) while receiving ESWT with 2000 impulses at a treatment frequency of four Hz and an energy flux density (EFD) equivalent to two to three bars. The 15 participants in Study Group B underwent ESWT with 500 impulses at a frequency of 4 hertz and an EFD equivalent to 2-3 bar working pressure with CDT. Control Group C (n=15) got only CDT. The treatment was administered twice weekly for eight consecutive weeks. Pre- and post-study assessments included round measurement by tape of the following locations: hand, wrist joint, fifteen centimeters from wrist joint, elbow joint, seventeen centimeters from elbow joint, and the end of the arm close to the axillary fold; volumetric evaluations of water displacement; ultrasonographic measurements of skin thickness; as well as the lymphedema life impact scale (LLIS) for QOL.

Results: a significant difference was found among three groups post-treatment ($p<0.05$) in all outcome measures, however ESWT with 2000 impulse demonstrated superior outcome measures compared to lower dose.

Conclusion: this study provides novel insights by being the first to examine the effects of different impulse dosages of ESWT in patients with stage 2 and 3 post-mastectomy lymphedema. The results indicates that ESWT may play a promising role in reducing lymphedema and improving patient outcomes, particularly when applied with methodological rigor and supported by multiple evaluation tools.

Key words: Extra corporeal shock wave therapy, complete decongestive therapy, LLIS, post mastectomy, Secondary lymphedema, ultrasonography.

INTRODUCTION

A malignant tumor originating from breast cells is referred to as "breast cancer" (1). Cancer cells have the potential invade neighboring healthy breast tissue and spread to the lymph nodes located under the arm, which are little organs responsible for filtering out harmful chemicals in the body. The lymph nodes are a potential entry point for cancer cells to other organs and tissues in the body. When discussing breast cancer, the term "stage" describes the extent to which the disease has progressed beyond the initial tumor (2)

Breast cancer-related lymphedema (BCRL) is a severe and disabling side effect of breast cancer therapy that is characterized by edema in the upper extremities caused by inadequate lymph drainage. This condition is persistent, progressive, and treatment-resistant; it often manifests between 18 and 24 months following breast cancer therapy (3). Lymphedema is a common side effect of breast cancer therapy that may affect ranging from 0.2 percent to 65 percent of patients (4,5,6).

Ipsilateral arm problems with breast cancer therapy (7). Damage to the lymphatic system permanently reduces a region's transport capacity, making it more likely to develop lymphedema (8). Symptoms might include abnormal fluid collection in the interstitial spaces, which can cause chronic swelling in various parts of the body, including the arm, shoulder, neck, breast, or chest. Axillary node dissection is the most common cause, but sentinel node biopsy, radiation, lumpectomy, or trauma to the area may also cause it. (9).

Symptoms of post-mastectomy lymphedema (PMRL) might appear immediately following surgery or years later (10). There was evidence that PMRL causes social and psychological effects. Anxiety, depression, frustration, along with distress were among the psychological aftereffects. Disability, suffering, altered role function, and an absence of social support were all examples of social consequences. In particular, one's mental and social health suffered as a consequence of these events (11).

The occurrence of lymphedema can be affected by a variety of variables, including the depth of nodal dissection, the quantity of nodes removed, the quantity of affected nodes, the existence of extra capsular spread, the primary tumor's size and grade, co-morbidities, chemotherapy, axillary irradiation, surgical experience, dominant extremity, and body mass index (12,13, 14)

The edema in many patients' legs is more than just an esthetic issue. When edema is just starting or is rapidly increasing, stretching soft tissues may be rather painfull. Function may be impaired by moderate to severe edema, which, in extreme cases, might cause skin changes and further functional limitations. Swelling, regardless of how little, may induce severe psychological distress in certain individuals (15).

There are numerous physical therapy interventions that are potentially effective in treating lymphedema including various compression therapies, massage techniques, electro physical agents, exercise, and education. Unfortunately, these therapies are not standardized (16).

Complex decongestive therapy (CDT) is a technique used to treat lymphedema; it is a combined treatment program that has been recommended by a consensus panel of experts. CDT consists of: 1) education & skin care, 2) manual lymph drainage massage (MLD) 3) multilayered compression short stretch bandaging and 4) exercise. The first part, "phase I," was the reduction phase, and the second, "phase II," was the continuous, tailored maintenance phase (16).

The most common treatment for stage one to two secondary lymphedema represents a complex decongestive therapy (CDT) regimen. However, in stage three, which is marked by fibrotic and unresponsive tissue, the CDT program is less successful (17).

Thru cavitation and shear load pressures, extracorporeal shock wave treatment (ESWT) was shown to mechanically impact dermal and hypodermal fibrosis. Through mechano-transduction, it also has biochemical responses inside cells. Studies have shown that low-energy ESWT may improve perfusion in ischemic tissues by increasing cell proliferation, decreasing inflammatory reaction, and promoting angiogenesis (18).

Because fibrotic alterations may reduce the efficacy of any therapy, further therapies, including ESWT, may be required for advanced secondary upper extremity lymphedema after stage two.

Recently, a number of clinical investigations and randomized controlled trials (RCTs) have compared the efficacy of low-energy ESWT in combination with CDT for patients with BCRL. Lymphedema patients' arms showed decreased volume, circumference, along with skin thickness after ESWT, according to Bae et al. (20). Researchers Cebbici et al. (21) found that ESWT enhanced breast cancer patients' functional status and quality of life (QOL). The best number of impulses of ESWT is not detected to be recommended for this case. So, this study aims to explore the most effective number of impulses of ESWT on the secondary upper limb lymphedema.

MATERIALS AND METHODS

This research was conducted out on forty-five female patients treated with radical mastectomy with chemotherapy and radiation accompanied by unilateral secondary upper extremity lymphedema (stage two, three) were recruited from Police hospitals mainly El Agoza. Age range from 35 to 65 years. This study was done from April 2023 to March 2025 in El Agoza Police hospital. Patients were divided with single-blind, prospective, randomized, controlled study into three equal groups, they experienced a mastectomy, either a modified or radical one, along with removal of lymph nodes from the axillary region and subsequent radiation and chemotherapy. Ten patients were assigned to each group. In Group A, patients had ESWT with 2000 impulses with a frequency of 4 hertz and an EFD equivalent to 2-3 bar working pressure with CDT. Treatment for Group B included ESWT with 500 impulses at 4 hertz and an EFD equivalent to 2-3 bar with CDT. Only Group C got CDT. The course of therapy consisted of eight weeks of twice-weekly sessions. Based on the Foldi classification, the lymphedema severity in all individuals was between 2 and 3 **(22).**

MATERIALS:

Study design:

To examine the study's goals, a double-blind, randomized, controlled trial was used. The faculty of the Physical Therapy Cairo University's ethical committee gave their approval to this research (P.T.REC/012/003318). Clinical Trials.gov has recorded it under the NCT06278298 ID.

Sample size calculation

According to Abdelhalim and Samhan (2018), affected side's circumference was used to calculate the sample size. The study included three groups, having the effect size was 0.65. The statistical tests used were F test, MANOVA, repeated measures within as well as between interaction, and a 95% power level at α = 0.05. A total of 45 people, with 15 in each group, are needed for the study, with a minimum suitable sample size of 40 subjects and an additional 5 subjects (12%) for dropouts. The sample size was determined using the G*Power program, specifically version 3.0.10 (Figure 1).

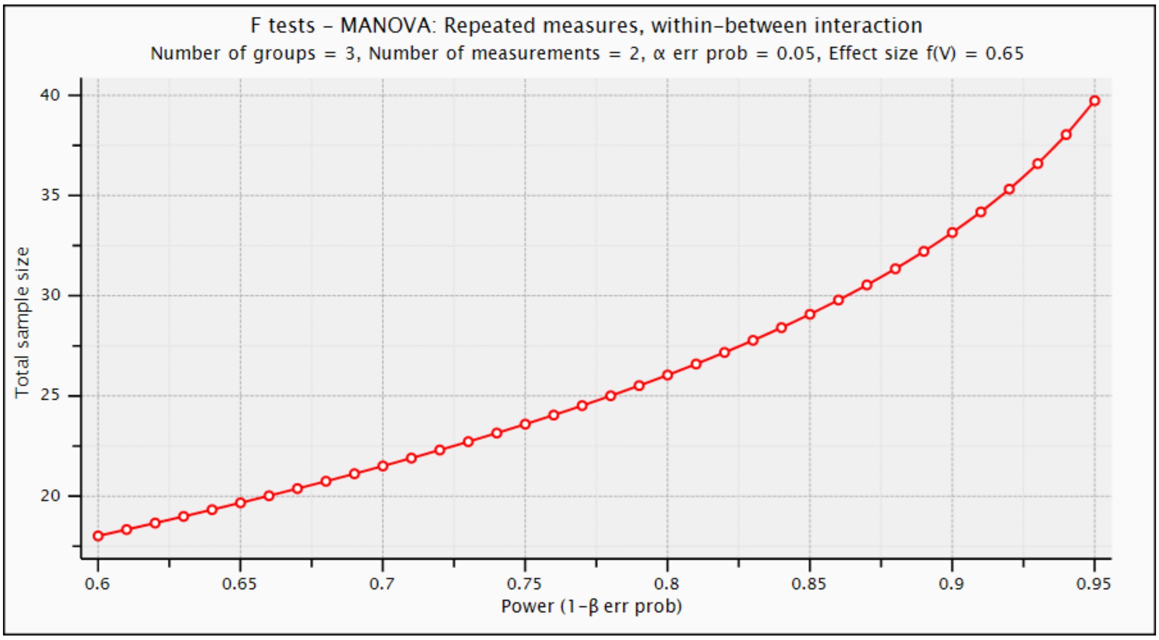


Figure (1): Sample size calculation

Participants and Eligibility

An overall 60 female patients having post mastectomy related upper limb lymphedema referred by an oncologist from police authority hospitals were initially screened for participation in the study. After applying the eligibility criteria, 15 patients were excluded due to not fulfilling the inclusion requirements or declining to participate. Finally, 45 eligible patients were enrolled and randomly assigned into three equivalent groups, with fifteen patients within each group. (figure 2).

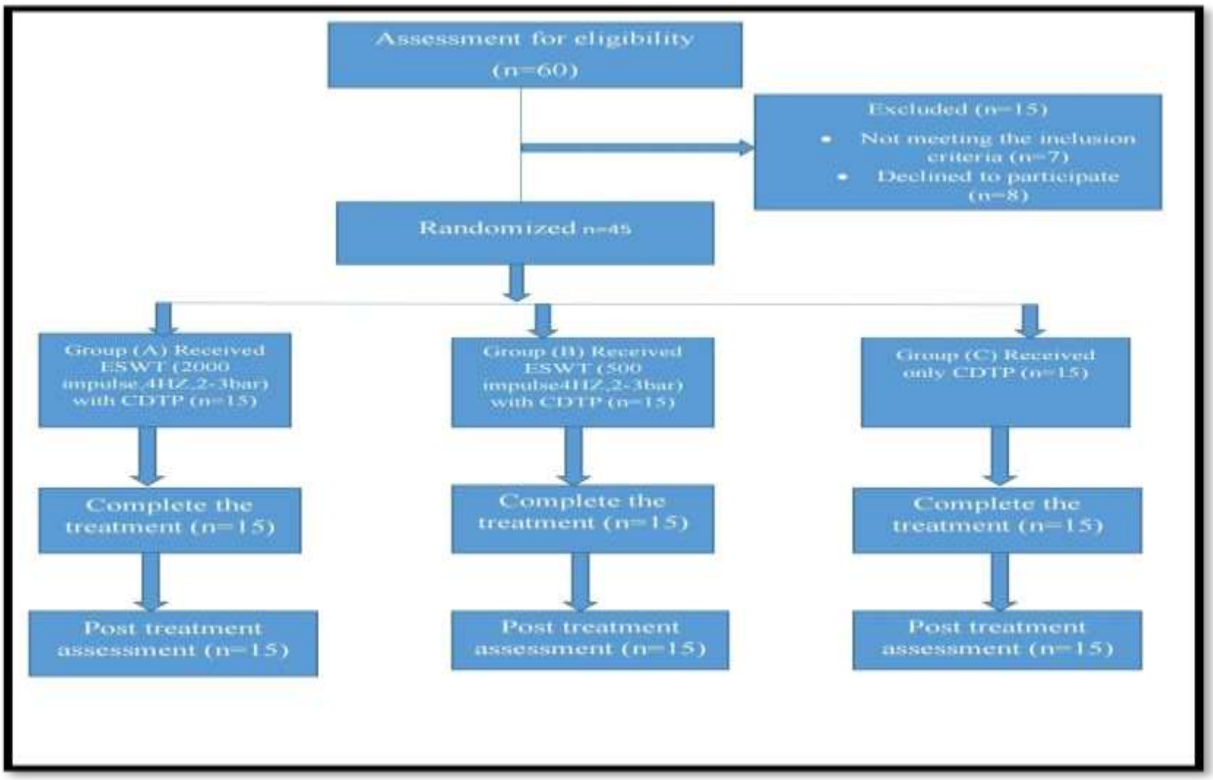


Figure (2): Flowchart of Eligibility

Statistical procedures:
Statistical analysis was performed on the data collected utilizing:
- Mean and standard deviation are examples of descriptive statistics. We employed analysis of variance (ANOVA) in inferential statistics to compare individual characteristics across the three groups.
- The normality of the data distribution was tested using the Shapiro-Wilk test.
- The dependent variables were compared within as well as between groups using repeated measures MANOVA.
- An analysis was carried out utilizing SPSS for Windows, version 20, developed by SPSS, Inc. of Chicago, IL.
- A p-value less than 0.05 will be considered statistically significant.

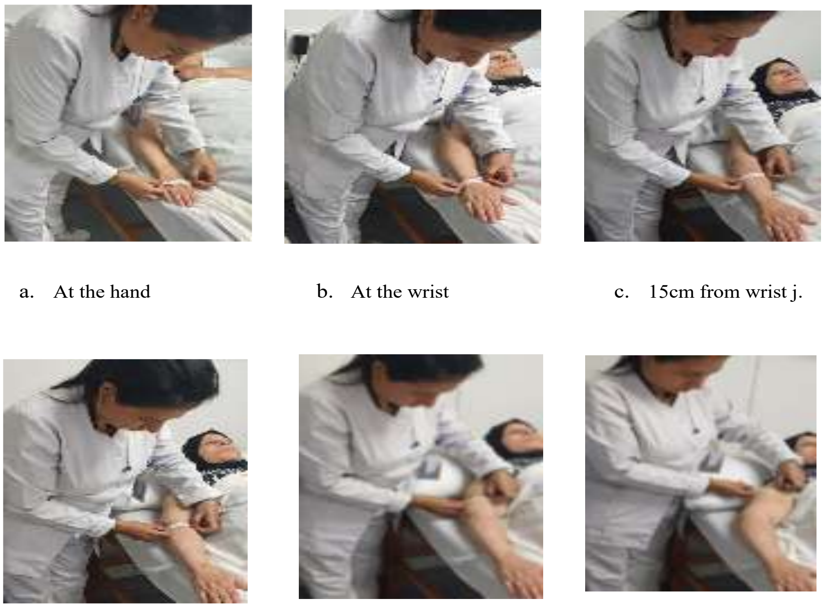
Evaluation procedure:
- **Flexible tape**: it was used to measure the round circumference.
- **The lymphedema life impact scale (LLIS)**: lymphedema's impact upon their QOL.
- **Ultra sonography (US)**: was used to detect skin layer thickness.
- **Volumetric measurement**: it was used to measure amount of edema.

Treatment procedure:
- **Extracorporeal Shock Wave Therapy (ESWT)**: effective in pain alleviation, reduce inflammation, improve vascularization, assist lymph angiogenesis, break the fibrotic tissue and improve lymphatic system function.
- **Complete decongestive therapy (CDT)**: It involves skin care, exercising to increase lymph flow, using compression bandages, and draining the lymphatic system.

METHODS

Evaluation procedure:

Circumferential round measurements with tape measurement: From supine lying position with the upper limb relaxed and extended, round measurements using a tape was used to measure the upper limb edema at the following points: at the hand, wrist joint, 15cm from wrist joint, elbow joint, 17cm from elbow joint in addition to at the end of the arm as in Figure 3.



a. At the hand
b. At the wrist
c. 15cm from wrist j.
d. At the elbow joint
e. 17cm from elbow joint
f. At the end of the arm

Figure (3): Tape Measurement for Upper Limb at 6 points a, b, c, d, e and f

Volumetric measurement:
The subjects were assessed upon arrival before commencing the sessions. They were reassessed at the end of the sessions. The apparatus was disinfected with boiling water and Dettol between every measurement by the assisting nurse. The level of water was measured and recorded prior to the beginning of the assessment **(23).**

- Fix a point as a starting point.
- All participants were permitted to be in standing posture close to the device and dipped her straight upper extremity inside the container
- The height of the displaced water was measured in cm.
- As shown in the figure (4), the volume of water displaced using the upper extremity with lymphedema compared with the unaffected limb was calculated by multiplying the difference among the two measurements (pre and following immersion) by the sectional area of the container.

Figure (4): Volumetric measurement by water displacement for upper limb lymphedema

- **The lymphedema life impact scale LLIS measures:**
  a. Physical symptoms (such as pain, heaviness, stiffness, and strength).
  b. Effects on the lives of people with primary or secondary lymphedema of the upper extremities in terms of psychosocial aspects (such as body image, intimacy, socializing, etc.) and functional aspects (such as duties at home or at work, recreational activities, etc.) (24).
- **Ultrasonography:**
  - Bench adjustments: this included adjustment of the bench height, support at zero inclination angle; the subject position was sitting position at right angle with semi flex elbow joint in pronation.
  - Ultrasound probe position: at lateral aspect of the extensor muscles of the forearm just below the elbow joint at most fibrotic area as in figure (5).

Figure (5): Ultrasonography for upper limb lymphedema

Treatment procedure

- **ESWT (group A):**

With ESWT, the treatment frequency is 4 hertz, and the EFD is 2 bar (21) and there is also a working pressure of 2 bar along with CDT) (21) Figure (6)

Figure (6): ESWT with 2000 impulses, the treatment frequency = 4 HZ & the EFD 2 bar

- **ESWT (group B):**

In addition to CDT, ESWT using 500 impulses each has a treatment frequency of 4 hertz and an energy flow density equivalent to 2 bar operating pressure (Figure 7) (25).

Figure (7): ESWT with 500 impulses, the treatment frequency = 4 HZ & the EFD 2 bar

- **Complete Decongestive Therapy (group C):**
    1) Manual Lymph Drainage: which is designed to activate the lymphatic system, activate the anastomosis between the lymphatic water sheds, make proximal evacuation and direct the congested lymph toward the nearest active lymph node.
    2) Skin care to keep the skin clean, healthy.

3) Bandaging with multi-layer of short stretch bandages with different diameter to reach pressure gradient where it is higher distally and lesser proximally.
4) Free active exercise for the upper limbs to activate the maximum number of muscles to increase the working pressure under the bandage.

- Manual lymph drainage:

The subject was relaxed in comfortable supine lying position on examination table. MLD started with activation of cervical and axillary lymph nodes at contralateral side, stationary circles applied with both hands at the pectoral aspect of the ipsilateral axillary lymph nodes towards the contralateral axilla empting of the ipsilateral quadrant, activation of inguinal axillary anastomosis, diaphragmatic breathing exercise against therapist hand at five points to empty deep and superficial abdominal lymph nodes (fig. 8,9),finally light strokes of MLD start from proximal, middle and distal regions of the edematous upper limb.

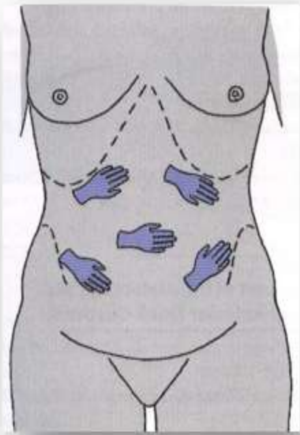


Fig. (8) A: the five points technique for deep abdominal lymph nodes *(Foldi et al., 2006)*

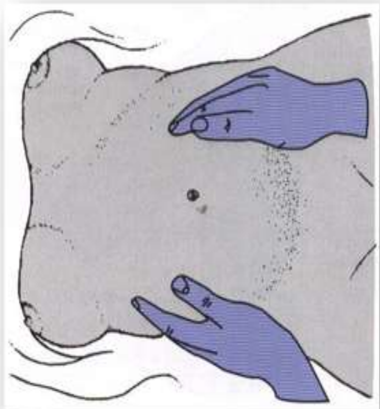


Fig. (8) B: the five points technique for superficial abdominal lymph nodes *(Foldi et al., 2006)*

Fig. (9a): The five points technique for superficial abdominal lymph nodes

Fig. (9b): Light stroke of MLD at proximal region of the edematous upper limb.

Fig. (9c): Light stroke of MLD at middle region of the edematous upper limb.

Figure (9): light stroke of MLD at proximal and distal region of the edematous upper limb.

- Skin care:
  Skin folds were cleaned with white alcohol, cleaned and dried well, antifungal & low ph cream were used to keep the skin moister & healthy.
- Compression therapy with short stretch bandages:
  Padding and multilayer short stretch bandages (Lohman & Raucher) were applied fro
  m the fingers till up the edematous part in figure of eight pattern, maximum compression is applied distally and decrease proximally (Figure 10).

(a) Tubular linen bandage

(b) Applying padding layers of non-woven cotton linen bandage

(c) Applying digit bandages

(d) Applying short stretch bandages

(e) Upper limb after applying short stretch bandages

Figure (10): Compression therapy with short stretch bandages illustrated in figures a, b, c and e

- **Free active Exercise:**

Restoring range of motion (ROM), increasing muscular strength, restoring or optimizing function of the upper extremities, and controlling swelling are the goals of supervised exercise regimens for individuals with lymphedema. Reduced lymphedema may be achieved only by losing weight (26)

Due to the fact that exercise and weight loss aid in the prevention of breast cancer, the remedial exercise is crucial (27).

Free active exercise for the upper limb in the form of; 15 times flexion, 15 times extension, 15 times and abduction of shoulder joint (Figure.11).

Figure (11): Free active exercise for the upper limb with short stretch bandages

Duration of treatment of CDT:
MLD was applied for 45 min followed by skin care; bandaging and active free exercise for 15 min. Frequency of treatment was 2 sessions/week for 8 weeks. This time between sessions allows decongestion and protein re-absorption.

Statistical analysis:
An alpha level of 0.05 was used for statistical analysis and comparisons with the outcome measures in SPSS for windows version 23 (SPSS, Inc., Chicago, IL). The data were examined for the existence of extreme scores, homogeneity of variance, in addition to the normality assumption. The measured variables were found to have a normally distributed distribution, according to the Shapiro-Wilks test ($p > 0.5$). All results are presented as means with standard deviations. The combined impact of all outcomes was compared among the groups using a two-way mixed design MANOVA. Every outcome measure was subjected to follow-up univariate ANOVAs with Bonferroni correction when MANOVA showed statistical significance. This was done in order to protect against type I error.

Results:

Demographic Characteristics: The subjects characteristics of the three groups was shown in Table (1). With a p-value of 0.05 or above, no statistically significant differences were found in the general characteristics of the patients among the three groups.
The impact of therapy on the assessed variables was examined using mixed-design multivariate analysis. With Wilk's A = 0.15, $F (18, 68) = 5.95$, P-value < 0.001, and Partial Eta Squared ($\eta 2$) = 0.61, a statistically significant difference was found between the groups. In addition, the time (pre-post treatment) had a statistically significant impact with Wilk's A = 0.01, $F (9, 34) = 411.4$, p-value < 0.001, Ɛ2 = 0.99, and for the interaction among groups and time, with Wilk's A = 0.06, $F (18, 68) = 12.33$, p-value < 0.001, Ɛ2 = 0.77.

Between-groups comparison: Baseline and after eight weeks of intervention
According to table (2-3), the three groups did not differ significantly at baseline in any of the evaluated variables (P-value > 0.05). As demonstrated in tables (2, 3, 4), there were statistically significant differences among groups A, B, and C following eight weeks of intervention on all evaluated variables, favoring group A (P-value < 0.05).

Within-groups comparison

As indicated in Table 4, statistically significant differences were detected in all measured variables when comparing the findings from before and after the intervention in groups A, B, and C. favoring Group A with a p-value of less than or equal to 0.05.

Table 1: Baseline Demographic Characteristics of participants (N=45) *

Characteristics	Group A (n=15)	Group B (n=15)	Group C (n=15)	F-value	P Value
Age(years)	**51.8±8.18**	**53.93±7.31**	**52.6±9.35**	0.25	0.78
Weight(kg)	**88.97±6.31**	**90.83±9.4**	**93.23±6.54**	0.77	0.47
Height(cm)	**161.2 ±5.2**	**160.47 ±4.66**	**160.93 ±3.22**	0.11	0.9
BMI (kg/m²)	**34.55±2.05**	**35.36±4.43**	**36.03±4.8**	0.52	0.6

BMI, body mass index; X^2, Chi Square; * Data are mean± SD for all demographics; P-Value < 0.05 indicate statistical significance

Table2. Clinical characteristics of participants at baseline and after 8 weeks' intervention (N=45) *

Outcomes	Time	Group A (n=15)	Group B (n=15)	Group C (n=15)	F-value	P-Value
Upper extremity circumferential at six levels (cm)						
Hand level 1(cm)	**Baseline**	21.77±1.07	21.24±2.55	20.8±1.57	1.06	0.36
	After 8 weeks	14.52±1.3	12.62±0.99	18.35±0.7	52.61	0.001
Wrist level 2 (cm)	**Baseline**	22.03±1.32	22.34±1.5	22.27±1.83	0.17	0.85
	After 8 weeks	16.53±0.92	18.45±1.47	20.14±1.95	21.34	0.001
15cm from wrist joint level3 (cm)	**Baseline**	34.29±2.65	33.39±3.29	34.07±1.65	0.49	0.62
	After 8 weeks	26.43±1.94	29.29±2.08	31.45±1.8	25.18	0.001
Elbow level 4 (cm)	**Baseline**	34.47±1.72	34.28±2.54	35.19±2.09	0.75	0.48
	After 8 weeks	25.83±1.93	29.75±2.18	32.29±1.63	42.92	0.001
17 cm from elbow joint level 5 (cm)	**Baseline**	41.92±2.33	41.8±3.82	42.2±3.02	0.04	0.96
	After 8 weeks	31.63±1.94	35.56±3.86	39.28±4.47	17.08	0.001
End of the arm level 6 (cm)	**Baseline**	40.68±4.44	39.67±3.11	40.18±2.65	0.32	0.73
	After 8 weeks	32.34±1.88	35.11±3.88	38.13±2.78	28.18	0.001
Water displacement (cm³)	**Baseline**	4267.4±868.16	4185.53±609.5	4482.67±581.03	0.73	0.49
	After 8 weeks	1084.4±227.9	2364.47±365.36	3447.93±532.31	134.37	0.001
Skin thickness (mm)	**Baseline**	32.01±2.65	31.86±1.74	32.53±2.41	0.35	0.71
	After 8 weeks	16.15±2.83	22.35±1.5	26.33±1.83	86.91	0.001
LLIS (score)	**Baseline**	44.47±5.63	43.6±2.85	43.33±3.24	0.31	0.73
	After 8 weeks	10.4±2.23	17.8±3.28	25.8±2.88	111.09	0.001

* Data are mean± SD, P-Value < 0.05 indicates statistical significance; cm: centimeter; mm, millimeter; LLIS: lymphedema life impact scale.

Table 3. Within group changes after 8 weeks of intervention

Outcome	Group A (n=15)		Group B (n=15)		Group C (n=15)	
	MD (95% CI)	P-Value	MD (95% CI)	P-Value	MD (95% CI)	P-Value
Hand level 1(cm)	7.25 (6.27, 8.23)	0.001	4.62 (3.64, 5.6)	0.001	2.45 (1.47, 3.43)	0.001
Wrist level 2 (cm)	5.47 (4.77, 6.18)	0.001	3.89 (3.19, 4.6)	0.001	2.13 (1.42, 2.84)	0.001
15cm from wrist joint level3 (cm)	7.87 (6.63, 9.1)	0.001	4.09 (2.86, 5.33)	0.001	2.61 (1.38, 3.85)	0.001
Elbow level 4 (cm)	8.64 (7.62, 9.66)	0.01	4.53 (3.52, 5.55)	0.001	2.9 (1.88, 3.92)	0.001
17 cm from elbow joint level 5 (cm)	10.29 (8.58, 12.01)	0.001	6.36 (4.64, 8.08)	0.0001	2.92 (1.2, 4.64)	0.001
End of the arm level 6 (cm)	8.34(6.65,10.03)	0.001	4.56(2.87,6.25)	0.001	2.05(0.36,3.74)	0.02
Water displacement (cm^3)	3183(2812,3554)	0.001	1821.07(1450.06,2192.07)	0.001	1034.73(663.73,1405.74)	0.001
Skin thickness (mm)	15.86(14.6,17.13)	0.001	9.51(8.24,10.77)	0.001	6.21(4.94,7.47)	0.001
LLIS (score)	34.07(31.92,36.21)	0.001	25.8(23.65,27.95)	0.001	17.53(15.39,19.68)	0.001

MD, Mean Difference; CI, confidence interval; P-Value < 0.05 indicates statistical significance; cm: centimeter; mm, millimeter; LLIS: lymphedema life impact scale

Table 4. Between Groups Effects after 8 weeks of intervention

Outcome	Group A vs Group B		Group A vs Group C		Group B vs Group C	
	MD (95% CI)	P-Value	MD (95% CI)	P-Value	MD (95% CI)	P-Value
Hand level 1(cm)	-2.1(-3.03, -1.17)	0.001	-3.83(-4.77, -2.9)	0.001	-1.73 (-2.67, -0.8)	0.001
Wrist level 2 (cm)	-1.89(-3.26, -0.52)	0.004	-3.59(-4.96, -2.22	0.001	-1.69(-3.06,-0.32)	0.01
15cm from wrist joint level3 (cm)	-2.87(-4.64,-1.1)	0.001	-5.03(-6.8,-3.26)	0.001	-2.16(-3.93,-0.38)	0.01
Elbow level 4 (cm)	-3.92(-5.67, -2.17)	0.001	-6.46(-8.21, -4.71)	0.001	-2.54 (-4.29, -0.79)	0.001
17 cm from elbow joint level 5 (cm)	-3.93(-7.2, -0.67).	0.01	-7.65(-10.92, -4.39)	0.001	-3.72(-6.99, -0.45)	0.02
End of the arm level 6 (cm)	-2.77(-4.69, -0.84).	0.003	-5.79(-7.72, -3.87)	0.001	-3.03 (-4.95, -1.1)	0.001

Water displacement (cm^3)	-1280.07(-1640,-920.12)	0.001		-2363.53(-2723.48,-2003.59)	0.001		-1083.47(-1443.41,-0.723.53)	0.001
Skin thickness (mm)	-6.2(-8.14,-4.26)	0.001		-10.17(-12.11,-8.23)	0.001		-3.97(-5.91,-2.03)	0.001
LLIS (score)	-7.4(-9.98,-4.82)	0.001		-15.4(-17.98,-12.82)	0.001		-8(-10.58,-5.42)	0.001

MD, Mean Difference; CI, confidence interval; P-Value < 0.05 indicates statistical significance; cm: centimeter; mm, millimeter; LLIS: lymphedema life impact scale.

DISCUSSION

This study was carried out to compare the impact of different dosages of ESWT in the treating post mastectomy lymphedema volume, skin thickness as well as Qol using the tape measurement to assess of upper limb circumference, volumetric water displacement apparatus as an objective tool for the assessment of the swelling, ultrasonography for the assessment of skin thickness and finally lymphedema life impact scale (LLIS) after two month of the treatment. The study was conducted from April 2021 to March 2025 in El Agouza police hospital.

Despite the increasing use of ESWT in lymphedema management, and up to the authors knowledge, no study has yet examined the differential impacts of applying (2000 impulses) versus (500 impulses) in patients with stage 2 and 3 upper extremity post-mastectomy lymphedema. Current literature has only focused on identifying the general therapeutic impact of ESWT or comparing it with other treatment modalities. Therefore, the specific role of different impulse dosages in reducing lymphedema volume and improving functional outcomes remains unexplored, highlighting the need for further research to establish its clinical significance.

Medical professionals now consider the pathogenesis of lymphedema to be an important issue. A buildup of protein-rich interstitial fluid impedes lymphatic function, resulting in a heavy, constricted, and chronically inflamed appearance. Tissue fibrosis and reduced lymphangiogenesis are outcomes of these pathological alterations. The proliferation, motility, and function of lymphatic endothelial cells (LECs) are all hindered by elevated levels in cytokines (28). We have come to the following conclusions on potential ideas about the mechanism that leads to the advantages of ESWT on BCRL. Initially, the LEC is pulled and their connections are opened when the skin is stretched, which applies tension to the anchoring filaments. The built-up fluid may be collected into the lymphatic lumen when the connections open (29). We hypothesized that ESWT may enhance lymphatic outflow by producing a comparable stretching effect. Also, ESWT decreases skin fibrosis, according to many investigations (30). The fibrosis that develops in BCRL patients as a result of the buildup of interstitial fluid may also be influenced by these results. Lastly, ESWT influences lymphangiogenesis' molecular components. Using a rat model of tail lymphedema, Serizawa et al. demonstrated that ESWT groups exhibited up-regulation of VEGF-C (31). Another investigation found that rabbit ears treated with ESWT had higher levels of VEGF receptor 3 (32).

In this research, four objective indicators were used to determine outcomes. Due to the anatomical differences in the subject's upper limbs, namely in the size, thickness, and location of muscles and skin folds, the affected arm was compared to the subject's non-affected arm (33).

Evidence suggests that ESWT may influence cellular lymphangiogenesis (the development of new lymphatic vessels) in animals, while its effects on lymphedema sufferers remain unknown. Its mechanical effects on tissues or its combination with cavitation and shear stress on the skin's hypodermis layer are possible (31&32). Researchers observed that ESWT reduced lymphedema circumference as well as skin fold thickness, two markers that improve skin firmness evaluation, in clinical trials involving patients with secondary lymphedema. Additionally, after ESWT, fibrotic regions or individuals with LE stage 3 showed resistance to the advancement of fibrosis (20).

Evidence suggests that ESWT may be useful in the management of lymphedema. By stimulating fibroblasts along with VEGF, prior research has shown that ESWT reduces secondary lymphedema and enhances lymphangiogenesis (31,32).

According to this research, lymphangiogenesis is responsible for improving the symptoms of lymphedema by increasing lymphatic outflow. Skin firmness and thickness are both enhanced by ESWT, according to research by Christ et al. (35), which also raises collagen production and the amount of elastic fibers. Thus, it is concluded that ESWT reduced the patients' forearm fibrosis by increasing collagen production and the amount of elastic fibers. Bae et al. found that seven patients having stage 3 BCRL reported alleviations in pain score, skin thickness, arm circumference, along with water volume after receiving ESWT (20). In a similar vein, Lee et al. found that patients with stage 2 BCRL and fibrosis who received ESWT had improvements in their symptoms without experiencing any major adverse effects (35). When ESWT was administered to BCRL patients, Mehtap et al. also found that lymphedema volume decreased and QOL improved. In addition, they found that these effects were long-lasting (21).

According to Maier et al. (2000), ESWT might be recommended as an additional treatment. Stage 3 lymphedema caused by breast cancer was treated with ESWT in his study (36).

In line with these theories, Hammer et al. (2002) found that people suffering from lymphedema due to breast cancer experienced less fibrotic skin alterations when their skin thickness was evaluated. The edema is exacerbated by lymphostatic fibrosis, which occurs when lymph buildup goes untreated. Lymphedema progresses from one stage to another, making fibrosis worse. Research using ESWT on multiple sclerosis patients suggests it could be useful for treating skin fibrosis as well. (37).

In the current study, the application of 2000 impulses of ESWT per session can be justified by previous evidence suggesting that this dose provides superior biological and clinical effects compared with lower impulse numbers (Wang et al., 2010) they demonstrated that shockwave protocols within the range of 500–2500 impulses significantly enhanced cell proliferation and tissue regeneration, whereas only 500 impulses produced a weaker therapeutic response. The authors concluded that approximately 2000 impulses may represent an optimal therapeutic response providing sufficient mechanical stimulation to trigger angiogenesis and tissue repair pathways, while avoiding the diminished efficacy or potential tissue overload observed with either very low or excessively high impulse counts. These findings support the rationale for selecting 2000 impulses as a more effective treatment dose than 500 impulses (38).

Walewicz et al. (2019) performed a RCT, 2.5 bars, 5 Hz, 7 minutes per session, twice weekly for 5 weeks, in patients suffering from low back pain (LBP). The findings indicated that RESWT provides more stable and beneficial outcomes with reduced risk of relapse compared to standard management programs. This suggests that ESWT, as a relatively invasive physical modality, may not provide immediate analgesic benefits but contributes to sustained improvement over time (39).

According to the findings of the statistical analysis conducted in this study, as the group A of ESWT (2000 impulses) plus CDT demonstrated significantly better outcomes compared to the group C CDT. Additionally, the group B of ESWT (500 impulses) plus CDT also outperformed the group C. Furthermore, the group A showed superior results when compared to group B. Therefore, ESWT with 2000 impulses can be considered the most effective in this study, as it achieved the best outcomes across all measurements tools used to assess ULRE patients in the following: Results showed a significant decrease in upper extremity circumference, LLIS, water displacement, in addition to skin folds' thickness. Overall, the number of sessions decreased from 20 to 16, and each session lasted no more than 10 minutes of ESWT, under the close supervision of the physical therapist. As a consequence, increased lymphangiogenesis, decreased numbers of fibrotic tissues, inflammatory cells, and fat cells, skin tissue renewal, and improved lymphatic drainage may explain why the ESWT groups (2000 and 500 impulses) in the current study showed a significant decrease in ULRE after breast cancer treatment.

This study possesses several notable strengths that add to its scientific value. First, it represents the first investigation to differentiate between the effects of high versus low impulses of ESWT in patients suffering from post-mastectomy upper limb lymphedema, thereby addressing an unexplored gap in the literature. Second, the inclusion of a well-defined control group enhances the internal validity of the trial and permits for a more reliable interpretation of the intervention’s effectiveness. Third, the use of four distinct evaluation methods for outcome assessment provides a multidimensional analysis, reinforcing the accuracy of the results and reducing the potential for bias related to single-measure evaluation. Collectively, these strengths highlight the novelty and methodological rigor of the study.

It is important to note that this research has several limitations despite its strengths. The results may not apply to larger populations because, first, the sample size was small. Secondly, there was no follow-up, so it's hard to say if the benefits were sustainable in the long run. Third, while four evaluation methods were used, the study did not include advanced imaging or biochemical markers, which could have provided deeper insights into the underlying mechanisms. Lastly, the study's potential lack of external validity is due to the fact that it was only carried out at a single center. It is important to take such limitations into account when evaluating the findings, since they might provide a starting point for future study.

In order to make the results more applicable to a broader population, future studies should expand upon current one by using bigger and more representative samples. To assess the long-term effects of therapy, longer follow-up periods are also recommended. The physiological processes behind the therapeutic benefits of ESWT may be better understood with the use of modern imaging tools in conjunction with biochemical markers. Multi-center trials are encouraged to enhance external validity, and future studies may also compare different ESWT protocols with other standard interventions to further clarify its role in comprehensive lymphedema management.

conclusion

this study provides novel insights by being the first to investigate the effects of different impulse dosages of ESWT in patients with stage II and III post-mastectomy lymphedema. The results indicates that ESWT may play a promising role in reducing lymphedema and improving patient outcomes, particularly when applied with methodological rigor and supported by multiple evaluation tools.

Conflict of Interest

The authors declare that there are no financial or personal relationships that could be perceived as influencing the work reported in this manuscript.

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