Assessment of Muscle Strength and Volume Changes in Patients with Breast Cancer-Related Lymphedema

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Keywords

Breast cancer · Lymphedema · Arm volume · Mastectomy · Muscle strength

Abstract

Introduction: To determine whether complete decongestive therapy (CDT) used in breast cancer-related lymphedema affects muscle strength in the affected arm while assessing the efficacy of the therapy itself. **Material and Methods:** Seventy-four patients with breast cancer-related lymphedema were included in this study. The demographic and clinical history characteristics of the patients were taken. The patients were then evaluated with measurements of extremity volumes and handgrip strengths using a hand dynamometer before and after the CDT. Data were then assessed using relevant statistical methods. **Results:** The mean CDT duration was 17.5 ± 8.93 days for the patients. Therapy resulted in significant improvement in the affected arm ($p < 0.01$). The difference between the arm with lymphedema and the other side was statistically significant, and this difference remained after the therapy ($p < 0.01$). The change in handgrip strength in the side with lymphedema was not found to be statistically significant after therapy ($p > 0.05$). Handgrip strength differences and volume differences before and after the treatment in the affected arm were not correlated ($p > 0.05$). **Conclusion:** Limbs affected with lymphedema were found to be weaker in handgrip strength and this weakness continued throughout the therapy. Strengthening exercises should be considered to be added into the treatment of patients undergoing CDT to gain better functional potential.

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Introduction

Breast cancer is one of the most prevalent types of cancer in women. Surgical treatments and chemotherapeutic agents combined with early diagnosis as a result of increased awareness have contributed to the increasing survival rates. Thus, increased survivability brings a higher incidence of complications associated with the therapies [1]. One of these complications is lymphedema, an accumulation of protein-rich fluid in surrounding tissues, and is thought to be a result of disruption of lymphatic drainage. It is a chronic and progressive condition and causes a considerable decline in quality of life through functional restrictions [2, 3]. Lymphedema results in pain, swelling, restricted range of motion (ROM), and weakness in the affected extremity. Lymphedema prevalence is found to range from 6 to 30% in patients who undergo axillary dissection for breast cancer [4, 5]. Decreased use of the affected arm also results in atrophy, weakness, and declined function due to decreased use [6]. The prevalences for the restricted ROM, pain, and weakness are revealed as 1.5–50%, 12–51%, and 18–23%, respectively [7–10]. Axillary dissection is found to cause more weakness when compared with sentinel node biopsy [11]. Conversely, changes in handgrip strength were found irrespective of surgery types or the presence of lymphedema [12]. Patients who underwent sentinel node biopsy were tested for their handgrip strength before and after the first year of surgery, and it was reported that they had a significant decline during this period [13, 14]. Such discrepancies between studies are thought to be a result of follow-up times, different sample sizes, or different types of dynamometers used for testing [15].

Although there are many findings in the field of breast cancer-related lymphedema (BCRL), studies investigating upper extremity functions are scarce, and the results of such studies lack consistency [7–10]. Also, no studies have evaluated the effects of complete decongestive therapy (CDT) on muscle strength. The purpose of this study was to reveal whether CDT contributed to a change in volume or handgrip strength in patients with BCRL.

Material and Methods

Recruitment

Among the patients who were admitted to our outpatient clinic, those with a circumferential difference between the arms and lymphedema diagnosis were recruited for the study. After a detailed history and physical examination, the diagnosis of lymphedema was confirmed for each patient. All subjects had either total mastectomy or breast-conserving surgery (BCS). Patients who accepted to undergo CDT and accepted to be involved in the study were included. Subjects with active infection or cancer with metastases, those who did not accept CDT, patients with vascular disease, rheumatic disease, upper limb deformity, any upper limb surgery history, bilateral lymphedema, or a history of transplantation were excluded. Among 100 patients with BCRL, 22 patients did not meet the inclusion criteria, and 4 were excluded due to missing data. A total of 74 patients were included in the study. The outcomes were recorded before the initiation of the therapy and immediately after the therapy.

Measurements

The clinical and sociodemographic characteristics of the patients were obtained, including age, height, weight, marital status, educational status, physical activity levels, dominant hand, smoking history, limb pain, chemotherapy and radiotherapy history, and weight change over time.

Handgrip Strength

Handgrip strength was measured using a JAMAR® hand dynamometer. These dynamometers have been used to assess handgrip strength in many studies for over half a century. Patients were asked to sit down with their shoulder adducted, elbow flexed (90°), and forearm in the neutral position. Measurements were taken in position 2 for women, and position 3 for men. These positions refer to the distance from the handle to the fixed part of the dynamometer. This distance is 4.8 cm for position 2, and 6.1 cm for position 3 (Fig. 1) [16]. A total of three measurements were taken in each patient, and the mean of the three measurements, which were taken with 1-min intervals, was recorded [17]. Before and after the treatment, patients' measurements were taken for both the affected and unaffected arms and recorded as kilogram-force (kgf).

Extremity Volume

Volume measurements were taken using the ulnar styloid process as an index point, and circumferential measurements were taken with 5-cm spaces from distal to the proximal. Using a computer program (Limb Volumes Professional version 5.0), the total volume of the arm was calculated and recorded before and after the treatment for both arms. All patients' measurements before and after CDT were taken by the same researcher.

Fig. 1. The dynamometer that was used to assess handgrip strength is shown. Note that each notch represents different positions, the most proximal notch being position 1, and the most distant notch being position 5, with this dynamometer being in position 2.

Intervention: Complete Decongestive Therapy

All patients were included in the CDT program. This therapy includes patient education, skin care, exercises, manual lymphatic drainage (self), and compression bandage therapy [18]. It is given in two phases. The first phase includes intensive therapy, which aims to reduce the volume of the extremity. The second phase aims to preserve these reductions of volume with long-term precautions and applications for lymphedema. Therefore, CDT refers primarily to the first phase of the therapy for this study, and its components are described in this section and in Table 1.

Patients were informed about nail and skin care for lymphedema because the abundance of the lymphatic fluid provides an optimal media for pathogens with its protein-rich nature, resulting in a higher risk for infections. The patients were asked to hydrate adequately and control their weight. All patients were prescribed lymphedema-specific exercises, consisting of ROM and resistive exercises for the upper extremities for 20 min every day, and were advised to engage in walking or jogging at light intensity for 30 min, for at least 5 days per week. They were specifically informed that exercise would not aggravate the severity of their lymphedema [19].

Patients were also taught about manual lymphatic drainage, which consists of slow and rhythmic movements, resulting in a gentle pressure over the skin. Having two phases, namely active and resting phases, manual lymphatic drainage helps the lymphatic fluid to move in the desired direction with the pressure in the active phase, and allows the fluid to migrate from interstitial space to the lymphatic vessels. Manual lymphatic drainage was given to the patients' affected extremity every day for 45 min [20].

Short stretch bandages were applied to the patients with self-manual lymphatic drainage. The intensive phase was given 5 days per week, and short stretch bandages were applied for 23 h a day with 1-h intervals. To increase the local pressure on the areas required, foam pads were added. Patients were screened with arm circumferential measurements once per week. After gaining a plateau in the volumes, patients were prescribed compression garments.

Table 1. Components of the CDT

Component	Phase 1	Phase 2
Skin and nail care	Always	Always
Weight control and self-care	Always	Always
Manual lymph drainage	At least once a day	According to individual needs
Compression	24-h bandaging (with 1-h intervals)	Elastic compression garments during the day
Physical therapy exercises	Daily	Daily
Walking	At least 5 days a week, 30 min	At least 5 days a week, 30 min

A booklet was also given to all patients. The booklet contained illustrations of the exercises, information about skin care, hydration, daily activities, and frequently asked questions. The booklet also contained information about the components of the therapy, which are mentioned in this section. All patients completed the therapy, and no adverse events were observed.

Statistical Analysis

Statistical analyses were performed using SPSS Version 22 for Windows software package (IBM Corporation). Descriptive statistics were used to evaluate demographic data. To assess whether data were compatible with normal distribution, the Shapiro-Wilk test was used. Dependent variables compatible with normal distribution were tested using *t* tests for dependent variables, and the Wilcoxon test was used for those with non-normal distribution. To find the final predictor, simple and multiple variable linear regression analyses were used. Spearman's correlation test was used to assess the correlation between variables. Statistical significance was set as $p < 0.05$.

Results

A total of 74 patients were included in this study, with a mean age of 56 ± 10.74 years. The clinical and sociodemographic characteristics of the patients are given in Table 2. Handgrip strength and body mass index (BMI) data are given in Table 3.

The mean CDT duration was 17.5 ± 8.93 days. The volume difference before treatment was $1,037.57 \pm 550.83$ mL, and after therapy, the difference was found as 563.66 ± 243.31 , which meant a 46% reduction. The difference between the arm with lymphedema and the other side was statistically significant, and this difference remained after the therapy ($p < 0.01$). Therapy resulted in significant improvements in the affected arm ($p < 0.01$).

The handgrip measurements before the therapy showed that the unaffected arm was stronger than the one with lymphedema ($p < 0.01$) and this significance remained after the therapy. The changes in handgrip strength on the side with lymphedema was not found to be statistically significant after therapy ($p > 0.05$). Handgrip strength and volumes in the unaffected arm were not shown to be improved after therapy ($p > 0.05$). BMI was also seen not to be changed significantly with the therapy ($p > 0.05$) (Table 3).

Table 2. Demographic and clinical data of the patients ($n = 74$)

Mean age $\pm$ SD, years	56 $\pm$ 10.74
Educational status, n (%)	
Illiterate	4 (5.4)
Elementary	37 (50)
High school	19 (25.7)
University	14 (18.9)
Marital status, n (%)	
Married	58 (78.4)
Single	5 (6.8)
Widowed	11 (14.9)
Occupation, n (%)	
Unemployed	48 (64.9)
Worker	1 (1.4)
Civil servant	3 (4.1)
Retired	18 (24.3)
Other	4 (5.4)
Physical activity level, n (%)	
Sedentary	11 (14.9)
Recreational walking	50 (67.6)
Regular exercise	13 (17.6)
Dominant hand, n (%)	
Right	67 (90.5)
Left	7 (9.5)
Smoking, n (%)	
No	55 (74.3)
Yes	12 (16.2)
Quit	7 (9.5)
Arm pain, n (%)	
No	41 (55.4)
Yes	33 (44.6)
Lack of use in the affected limb, n (%)	
No	72 (97.3)
Yes	2 (2.7)
Weight gain after surgery, n (%)	
No	36 (48.6)
Yes	38 (51.4)
CT, n (%)	
No	4 (5.4)
Yes	70 (94.6)
RT, n (%)	
No	7 (9.5)
Yes	67 (90.5)
Mean duration of complete decongestive therapy $\pm$ SD, days	17.5 $\pm$ 8.93
Mean number of removed lymph nodes $\pm$ SD, n	18.7 $\pm$ 8.6

Table 3. Effects of lymphedema therapy on outcomes

	Before therapy	After therapy	<i>p</i>
Arm with lymphedema volume, mL	3,743.28±861.82	3,231.54±646.63	<0.01
Arm without lymphedema volume, mL	2,720.81±535.16	2,711.15±539.62	0.637
Comparison of AL and HL volumes (<i>p</i>)	<0.01	<0.01	
Arm with lymphedema handgrip strength, kgf	17.86±4.95	17.73±4.67	0.644
Arm without lymphedema handgrip strength, kgf	19.93±4.46	19.91±4.48	0.937
Comparison of AL and HL handgrip strength (<i>p</i>)	<0.01	<0.01	
BMI, kg/m ²	30.70±5.45	30.50±4.98	0.154

Values are given as mean ± SD. AL, arm with lymphedema; HL, healthy limb.

Correlation analyses conducted between handgrip strength differences and volume differences before and after the treatment in the affected arm revealed no significant correlation ($p > 0.05$). The number of removed lymph nodes was also not found to be correlated with any of these parameters ($p > 0.05$).

Discussion

In this study, which evaluated the change in limb volumes and handgrip strengths in patients with BCRL, it was found that patients had lower handgrip strength in the affected arm. With CDT, a significant reduction was observed in the limb with lymphedema, but the significance of the difference between arms persisted. After CDT, there was no significant change in handgrip strength, with a slight reduction in both arms. The arm with lymphedema was seen to show a decrease in handgrip strength more than the unaffected arm.

All patients took CDT and the volume difference reduced from $1,037.57 \pm 550.83$ mL to 563.66 ± 243.31 mL, a reduction of 46% [21, 22]. This finding is compatible with other studies that investigated the effectiveness of CDT in patients with BCRL, which are reported to be around 30%.

This study also found that the affected arm had a lower grip strength than the unaffected arm. Although some studies reported that there was no difference between arms in patients with lymphedema [12], others claimed that this difference was significantly high [13, 14]. The decrease before treatment in the affected arm was attributed to the relatively lower use of that arm, pain after surgery, lymphedema, accompanying rotator cuff disorders, adhesive capsulitis, neuromuscular disorders, or dermatitis [6, 22].

Although not statistically insignificant, we found that the handgrip strengths decreased after therapy in the affected arm. These findings may be due to the less frequent use of the affected arm or a decrease in the perfor-

mance of the activities of daily living with the bandaged arm. Although all patients were prescribed an exercise program targeting the lymphedema, strengthening was not a part of this program. It might be valuable to show a possible weakening of the muscles after CDT. Most of our patients were tentative about using their affected arm, and this situation usually results in muscle atrophy, weakness, and functional restrictions [6]. However, active resistive exercise was found not to increase the volume of the limb and resulted in a decrease of volume in the proximal arm in a study [23]. Thus, it might be reasonable to add strengthening exercises to treatment while patients undergo CDT. Given that no other studies were found to be investigating the relationship between CDT therapy and handgrip strength, there might be a need for further studies with more patients to investigate this relationship.

Obesity is a risk factor for the development of lymphedema, and a positive correlation is present according to the evidence [24, 25]. BMI values higher than 30 kg/m^2 were found to be a risk factor for lymphedema, but values between $25\text{--}30 \text{ kg/m}^2$ were not found to be risk factors. Additionally, weight gain of more than 10 pounds was also found to be a risk factor for the development of lymphedema in the same study [26]. Obesity is known to be associated with poor responses to lymphedema therapy, and patients are advised to restrict their caloric intake, mostly in the form of carbohydrates and fat, and to lose weight. Our study has not found that BMI decreases were significant. A study found that volumes improved insignificantly in diet groups and that weight loss was correlated with decreases in volume [27]. Another study reported that weight gain was a risk factor for lymphedema development in patients with breast cancer, and associated with worse response [28].

The strengths of our study can be defined as being the first study to investigate the relationship between handgrip strength and CDT, and the conduction of all measurements and therapies by the same individuals, creating standardization.

The relatively low number of patients can be considered a limitation of this study. Aside from the numbers, the same patients' healthy arms were considered as the control group; because these arms did not have lymphedema, it would be preferable to have a control group with lymphedema without treatment. However, due to ethical considerations and similar studies conducted in this field, the healthy arms of the same patients were chosen as the control group [11, 27, 28].

Conclusion

CDT is an effective method in the management of lymphedema secondary to breast cancer. Limbs affected by lymphedema are found to be weaker in handgrip strength and this weakness continued throughout the therapy. Strengthening exercises should be considered to be added into the treatment of patients undergoing CDT to gain better functional potential.

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Statement of Ethics

All participants in the study provided written informed consent to this work and agreed to the scientific use of their data. The study was conducted in accordance with the Declaration of Helsinki and was approved by the institutional ethics board of the Ege University Faculty of Medicine. ClinicalTrials.gov Identifier: NCT039458380.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

Musa Baklaci: literature review, analysis of data, and drafting the article. Sibel Eyigör: conception of the study and revising the article critically for important intellectual content. Göksel Tanıgör: literature review, language editing, and revising the article critically. Menekşe Özgür İnbat, and Sedef Çalışkan Kabayel: providing the therapy and revising the article critically.

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