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EFFECTS OF RESISTANCE EXERCISES AND COMPLEX DECONGESTIVE THERAPY ON ARM FUNCTION AND MUSCULAR STRENGTH IN BREAST CANCER RELATED LYMPHEDEMA

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ABSTRACT

The incorporation of resistance exercises into the lifestyle of patients with lymphedema is understudied and an emerging interest. We investigated the effectiveness and results of adding a moderate intensity resistance exercise program for 8 weeks in conjunction with intensive CDT for 1 or 2 weeks (depending on severity) on arm volume, arm function, QOL, and muscular strength in patients with breast cancer-related lymphedema. This prospective, pilot trial included forty-four patients with a history of breast cancer who were beginning complex decongestive therapy for lymphedema. They were assigned to either the intervention (n=22) or control (n=22) groups. The intervention comprised of resistance band exercises 5 times a week for 8 weeks. These were initially supervised during the intensive lymphedema treatment, but performed independently during the study period. Limb volume, muscular strength, and the European Organization for Research and Treatment of Cancer QOL Questionnaire C30 (EORTC QLQ-C30), EORTC-Breast Cancer-Specific QOL Questionnaire (EORTC QLQ-BR23), and Disabilities of Arm, Shoulder, and Hand (DASH) questionnaires were assessed at baseline and at 8 weeks. After 8 weeks, the intervention group demonstrated statistically significant differences ($p<0.05$) in the DASH score and muscular strength compared to the control group. Our results indicate that upper body resistance exercise demonstrates a positive effect on arm function and muscular strength without increasing arm volume in breast cancer related lymphedema during and shortly post intensive CDT lymphedema treatment.

Keywords: breast cancer, resistance band, TheraBand™, exercise, lymphedema severity, quality of life, complex decongestive therapy, CDT, randomized trial

Lymphedema of the arm following breast cancer surgery is one of the most common complications after curative treatment (1). Breast cancer treatment can damage lymphatic drainage causing retention of lymphatic fluid in the interstitial tissue of limbs and body areas and secondary lymphedema. The incidence of arm lymphedema depends on the extent of surgical treatment, number of removed lymph nodes, use of radiation therapy, and obesity (1). The reported incidence of lymphedema following breast cancer treatment varies due to lack of standard measurements and definitions (2). The incidence estimates are mostly available for the breast cancer survivor population, with rates ranging from 13% to 65%, depending on the criteria and assessment measures used (3,4).

Swelling can cause pain, discomfort, heaviness, distortion, and reduced mobility

and function (5), affecting quality of life (QOL) both physically and psychologically. The impact of lymphedema on QOL ranges from subtle to drastic, and even leaves sequelae including frustration, distress, depression, and anxiety, particularly in regard to body image (6). These effects have social ramifications on role function and social support as well as pain and disability. Even a relatively mild lymphedema can alter body image and cause significant impairment in physical and psychosocial function and QOL (6,7).

Previous recommendations to reduce the risk of lymphedema include limiting the use of the affected arm in activities of daily living to prevent excess demand on the affected arm (8,9). Traditionally, clinical guidelines recommend that women with lymphedema should avoid vigorous, repetitive upper body exercise to prevent lymphedema exacerbation (10). These recommendations limit certain daily living activities and can result in occupational and psychological problems. However, recent studies are reporting that lymphedema is unaffected by weight lifting exercises performed using the affected arm (11). Moreover, in randomized controlled trials (12-14), resistance exercises did not increase the risk or worsen lymphedema symptoms for patients who were diagnosed with lymphedema. Some studies have shown that progressive resistance training in the post-operative period provided benefit in range of motion without precipitating exacerbation of symptoms even with increasing its strength (12). Supervised weight training with the use of pressure garments was suggested to be safe and beneficial in improving limb strength and physical components for better quality of life for women without the risk of lymphedema (13).

Exercise improves mobility and muscular activity which lead to internal compression of lymph vessels. Intermittent pressure changes between muscles and external compression (bandages or compressive garments) can also stimulate lymphatic drainage. Additionally, lymph flow through the thoracic duct can be activated by changes in intrathoracic pressure caused by breathing exercises. These studies suggest that patients should be encouraged to maintain physical activity (14). Nevertheless, there exists controversy on the effect of resistance exercise, and Korpan et al (15) have concluded that further randomized trials are needed to verify which component or combination of components in this complex decongestive therapy works most effectively for patients. Since lymphedema patients can undergo considerable loss of muscle strength in the affected arm resulting in progressive decline in arm function in terms of fine and gross motor, we thought that a certain form of resistance training that helps more with muscle strength should be studied in-depth in regards to overcoming the unresolved issues in the current literature.

A resistance exercise with bands is a type of resistance exercise that is used for enhancing muscle strength in clinics. It can be used for cases that need to involve large range of motion and eccentric and concentric muscle contractions. Moreover, it is an easy and safe method which can be adjusted in intensity by choosing various strengths of rubber stiffness, and it enables moderate intensity exercises to be suitable for older people and patients with weakness. Previous studies have suggested that resistance exercise makes changes in the body composition (16) and physical function (17) and enhances quality of life among older people (18).

To date, there are no studies that have evaluated the impact of moderate TheraBand exercise with intensive complex decongestive therapy (CDT) on arm volume in lymphedema patients.

Thus, the purpose of the present study was to determine the effectiveness of resistance band exercise along with intensive CDT on arm function, muscular strength, quality of life, and arm volume, and how the effectiveness differed according to the severity of lymphedema.

METHODS

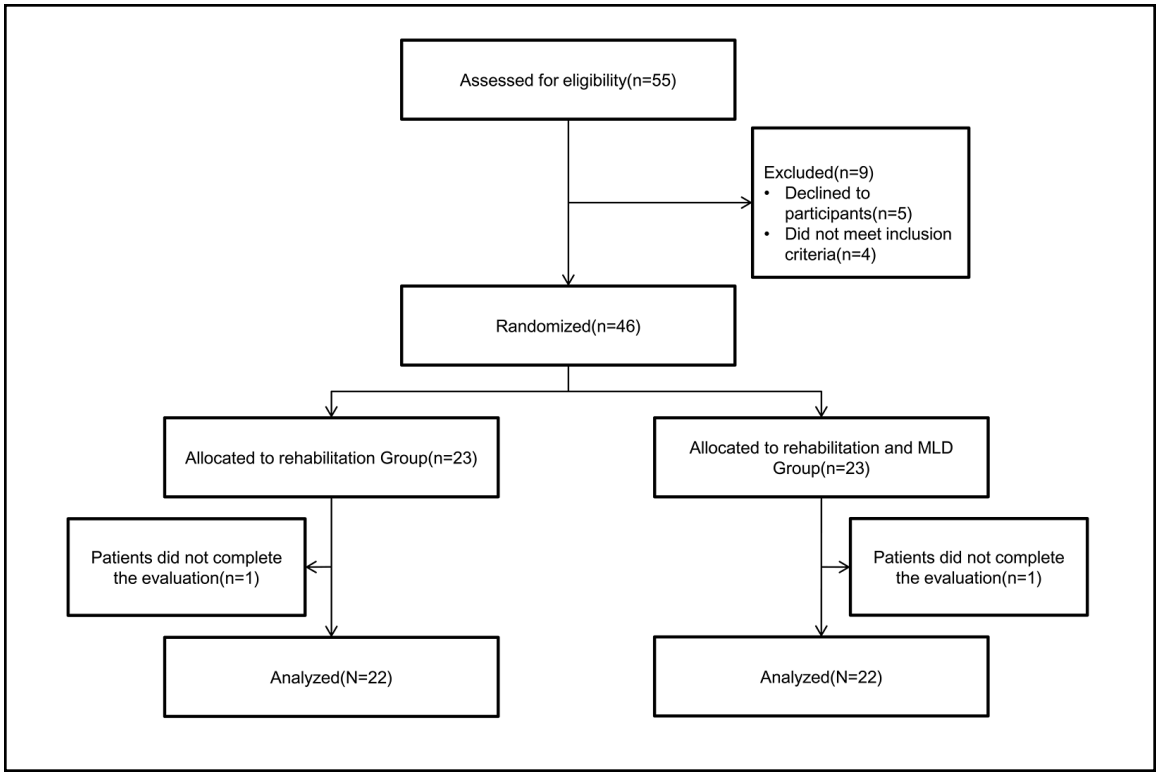

Fig. 1. Flow diagram of participants

Study Design and Ethical Conduct of Research

A total of 55 patients were enrolled. Nine participants discontinued due to exclusion or dropout and as a result, 46 patients were randomized. Two participants did not complete the last evaluation (*Fig. 1* Flow diagram of participants). Therefore, we included 44 breast cancer patients who visited our outpatient clinic for treatment of edema of the upper limbs after breast cancer surgery and/or radiotherapy. Sample size calculation was performed based on the recommendations of previous research, and 13 patients in each group (intervention vs control) were needed to demonstrate differences in upper body strength at 5% significance level with moderate effect size and 80% power (19).

Patients who were diagnosed with secondary lymphedema based on clinical assessment and lymphoscintigraphic findings were enrolled. Patients were randomly assigned to either the intervention group (n=22) or the control group (n=22). We measured the circumference of the forearm at 10 cm below the elbow and the circumference of the upper arm at 10 cm above the elbow. Then, we stratified the patients into two groups: those who had more than 2-cm difference in limb circumference (the severe group) and those who had less than 2-cm difference (the mild group). In addition, this classification was supported by lymphoscintigraphic findings which demonstrated increased uptake through dermal backflow in the severe group and lack of dermal backflow in the mild group.

The exclusion criteria included cancer recurrence and presence of other disease (arterial insufficiency, deep vein thrombosis, chronic venous insufficiency, heart or kidney

disease, and musculoskeletal disease). In addition, patients with skin problems, such as scar, inflammation, or infection were also excluded.

Both the intervention and control groups received CDT for 1 or 2 weeks. CDT consisted of manual lymph drainage, physical exercise, bandaging or stocking, and skin care. Patients with severe lymphedema who had more than 2-cm difference in limb circumference underwent CDT for 2 weeks with bandaging. Patients with mild lymphedema who had less than 2-cm difference in limb circumference, or had clinical symptoms, underwent CDT for 1 week with stockings.

Informed consent was obtained from all participants.

Assessments

All participants underwent evaluations of arm volume and muscular strength and completed the Disabilities of Arm, Shoulder, and Hand (DASH), the European Organization for Research and Treatment of Cancer QOL Questionnaire C30 (EORTC QLQ), and the EORTC-Breast Cancer-Specific QOL Questionnaire (EORTC QLQ-BR23) at baseline and after 8 weeks.

Stratified Randomization

Participants were assigned to either the intervention or control group in a 1:1 ratio according to mild and severe lymphedema. Twenty-two women were randomized to the resistance exercise group and 22 to the control (CDT) exercise group at a 1:1 ratio using a computer-generated allocation sequence.

Measures

QOL

QOL was evaluated with both the EORTC QLQ-C30 (version 3) questionnaire and the EORTC QLQ-BR23 breast cancer module supplement, which have been validated and cross culturally tested in various cancer populations (20). The self-administered EORTC QLQ-C30 questionnaire comprises 30 items that incorporate five functional scales (physical, functional, cognitive, emotional, and social performance); three symptoms scales (fatigue, pain, and nausea and vomiting); and QOL and overall health status scales. The BR23 assesses specific aspects of breast cancer and comprises 23 items with two scales: functional and symptomatic.

Arm Disability

The DASH outcome measure is a 30-item questionnaire designed to measure physical function and symptoms in people with any of several musculoskeletal disorders of the upper limb; at least 27 of the 30 questions must be completed for the score to be calculated. The questionnaire specifically asks patients to rate their function without regard to which hand/arm they use to perform the task. The assigned values for all completed responses are simply summed and averaged, producing a score out of five. A higher DASH score indicates a greater level of disability experienced by the patient.

Lymphedema Status

Limb volumes were calculated by measuring the circumference every 4 cm from the wrist to the axilla, using the formula $\sum \text{Circumference}^2/\pi$. The measurement was done by the same therapist before starting treatment and after 2 weeks of treatment (21).

Muscular Strength Measurement

Seven muscle groups were bilaterally measured using a hand-held digital dynamometer (Power Track II Commander, JTech Medical, Salt Lake City, UT, USA) with maximum isometric strength. The muscles assessed included the shoulder flexor, extensor, abductor, internal rotator, external rotator, elbow flexor, and extensor muscles.

Muscular groups were tested in the middle of the joint range of motion, and the dynamometer was placed vertically on the desired organ (22,23). The system was regulated so that it recorded the maximum contraction. For any group of muscles, a duration of 5 seconds was used to measure the maximum isometric contraction of each muscle group. Before performing the test, a sample test was performed once. The average of three contraction trials was recorded as the final number, and 2 minutes of rest was given between every contraction to avoid a decline in strength across trials due to fatigue. The patients were in a sitting position during testing (22).

Intervention

CDT

CDT was provided by a certified lymphedema therapist. CDT comprised the following steps: (1) an average of 30 minutes of manual lymph drainage involving a specialized gentle massage to stimulate the lymphatic system; (2) compression of the affected limbs via garment or multilayer, short-stretch compression bandaging with layers of fabric padding (3) exercises to enhance lymphatic pumping; and (4) meticulous skin care of the affected areas.

Resistance Exercise Program

Resistance band exercises were performed using TheraBand™ (Hygenic Corporation, Akron, USA) elastic tubing of different resistance levels (red, green). The handle-to-handle length of the elastic tubing was individually adjusted. Intensity of exercise was 6 on the OMNI Resistance which is considered same exercise intensity levels ranging from 60% of 1RM (24) for active muscle scale, indicating 'somewhat hard.' OMNI Resistance of 0 indicates 'extremely easy' and 10 indicates 'extremely hard.'

Resistance exercise comprised 3 sets of 10 repetitions of isolated shoulder flexion, isolated shoulder abduction and extension, and internal rotation and external rotation, with resistance provided by the tubing. Exercises were to be completed from the anatomical neutral position to 90° of shoulder abduction or flexion. Participants in the intervention group were advised to rest for 2 minutes between exercise sets. All exercises were performed against graded resistance provided by the tubing. The dosage (i.e., 3 sets of 10 repetitions, somewhat hard feeling, 5 times per week for 8 weeks) was prescribed to the intervention group according to the protocol recommended to improve 'high-intensity endurance and speed' using resistance (*Table 1*) (22).

Statistical Analysis

Statistical analysis was performed using SPSS version 18.0 software (SPSS Inc., Chicago, IL). We described demographic, clinical, and outcome variables by using means and standard deviations for continuous variables and percentages for categorical variables. Baseline descriptive statistics were compared using an independent t-test for continuous data and chi-square analysis for categorical data. Paired t-tests were used to compare difference of baseline and week 8 values of QOL, limb volume, arm disability, and muscular strength between the two groups. Mann-Whitney U Test was used to compare the post-treatment assessment parameters according to the severity between the two groups.

RESULTS

Characteristics of Participants

The average age of the participants was 49.7 in the intervention and 49.6 in the control group. A BMI over 25 was observed in 9% (intervention) and 18% (control) of participants. There were no significant differences between the intervention and control groups in terms of occupation status,

TABLE 1
Exercise Methods

Program components	Program details
Warm-up	Stretching exercises for the shoulder (shoulder flexion, extension, adduction, abduction, internal rotation, external rotation)
Strengthening	Shoulder flexor, extensor, abductor, internal rotator, external rotator, elbow
Exercise	flexor, extensor, wrist flexor, and extensor muscles
Intensity	10 repetitions with somewhat hard feeling Must be able to maintain posture and scapular stability (no winging of the scapula) Perform resistance band exercises OMNI Resistance scale 6: "somewhat hard"
Repetition sets	3 sets
Cool down	Stretching exercises for the shoulder (shoulder flexion, extension, adduction, abduction, internal rotation, external rotation)

average exercise frequency, education status, marriage status, economical status, lymphedema, chemotherapy, hormone therapy, stage, and surgical method (*Table 2*).

Comparison of the QOL, DASH, Arm Volume and Muscular Strength at Pre-Treatment between the Intervention and Control Groups

At baseline evaluation, there were no differences between the intervention and control groups in terms of functional and symptomatic aspects of QOL. In addition, statistically significant differences were not seen in terms of sexual function, and breast and arm symptoms in the EORTC QLQ-BR23, DASH score, muscle strength and arm volume (*Table 3*).

Comparison of the QOL, DASH, Arm Volume and Muscular Strength at Post-Treatment between the Intervention and Control Groups

At post-treatment evaluation, there were no differences found between the intervention and control groups in terms of functional and symptomatic aspects of QOL, arm volume, and muscular strength. The DASH score was significantly lower in the intervention group after treatment (P=0.001) (*Table 4*).

The Changes in QOL, DASH, Arm Volume, and Muscular Strength between the Intervention and Control groups after Treatment

The global health status, fatigue (EORTC QLQ-C30), arm symptoms (EORTC QLQ-BR23) and arm volume showed significant improvement after treatment in both intervention and control groups ($p<0.05$). Improvement after treatment was significant only in the intervention group for the following parameters; physical functioning, cognitive functioning, pain (EORTC QLQ-C30), breast symptoms (EORTC QLQ-BR23), muscular strength and DASH score ($p<0.05$) (*Table 5*).

Comparison of the Changes in QOL, DASH, Arm Volume and Muscular Strength between the Intervention and Control Groups According to the Severity of Lymphedema after Treatment

The global health status and physical functioning scores within the EORTC QLQ-C30 significantly improved in the intervention group who received resistance treatment compared with control, in the severe subgroup ($p<0.05$). The DASH score decreased in the

TABLE 2
Baseline Demographic and Clinical Characteristics of the Study Participants

Classification	Intervention (n = 22) Mean±SD	Control (n = 22) Mean±SD	*p*
Age	49.7±7.05	49.6±10.35	0.987
Occupation			
No employment	18 (82%)	15 (80%)	0.296
Part-time employment	0 (0%)	0 (6.6%)	
Full-time employment	4 (18%)	7 (13.3%)	
BMI*			
≥25	2 (9%)	4 (18%)	0.380
<25	20 (91%)	22 (82%)	
CDT period			
1 week	12 (54%)	10 (46%)	0.546
2 weeks	10 (46%)	12 (54%)	
Education level			
High-school education	8 (36%)	6 (86.3%)	0.517
University education	14 (64%)	16 (72.7%)	
University education	14 (64%)	16 (72.7%)	
Married	18 (81.8%)	19 (86.6%)	0.680
Single	4 (18.1%)	3 (13.3%)	
Economic status			
High	1 (4.5%)	1 (4.5%)	0.291
Medium	19 (86.6%)	15 (68.1%)	
Low	2 (9%)	6 (27.2%)	
Chemotherapy			
Yes	18 (81.8%)	16 (72.7%)	0.472
No	4 (18.1%)	6 (27.2%)	
Hormone therapy			
Yes	17 (77.2%)	18 (81.8%)	0.709
No	5 (22.7%)	4 (18.1%)	
Stage of cancer			
I (T1NO)	2 (9.0%)	1 (9.0%)	0.772
IIa (T1N1,T2NO)	7 (31.8%)	8 (36%)	
IIb (T2N1,T3NO)	8 (36.3%)	10 (46%)	
III (T1N2,T2N2,T3N1-2)	5 (22.7%)	3 (13.6%)	
Type of surgery			
Mastectomy	11 (0.5%)	10 (45.4%)	0.988
Lumpectomy	10 (45.4%)	10 (45.4%)	
Breast reconstruction	1 (4.5%)	2 (9%)	

* BMI: Body mass index; CDT: Complex decongestive therapy

TABLE 3
Mean Values Obtained for QOL, DASH, Arm Volume, and Muscular Strength at Pre-Treatment

Classification	Intervention (n = 22)	Control (n = 22)	*p*
EORTC QLQ-C30[a]			
Global health status/QOL	44.0±21.1	51.2±18.8	0.234
Functional Scales			
Physical functioning	70.6±15.0	66.3±19.5	0.422
Role functioning	60.9±20.1	61.4±29.9	0.941
Emotional functioning	60.9±20.1	61.4±29.9	0.941
Cognitive functioning	67.8±23.5	68.3±27.6	0.952
Social functioning	52.6±32.3	65.6±27.4	0.160
Symptom Scales			
Fatigue	50.0±23.5	44.3±23.3	0.426
Pain	42.8±20.9	35.5±27.7	0.335
Dyspnea	27.7±18.6	24.7±20.2	0.620
EORTC QLQ-BR23[b]			
Functional Scales			
Body image	42.1±34.7	46.8±26.4	0.619
Sexual functioning	76.1±30.2	86.9±19.4	0.168
Symptom Scales			
Breast symptoms	40.7±26.5	32.5±20.0	0.256
Arm symptoms	48.1±27.2	52.0±21.2	0.594
Sum of Muscular strength (N)	71.1±6.6	70.3±8.6	0.713
DASH (Score)[c]	34.8±18.6	30.2±18.3	0.412
Arm volume (mL)	2083.6±422.6	2130.6±322.0	0.680

[a]Quality of life questionnaire-cancer
[b]Quality of life questionnaire-breast
[c]Disabilities of Arm, Shoulder, and Hand

resistance group compared with control, in both mild and severe subgroups ($p<0.05$) (*Table 6*).

DISCUSSION

Muscle weakness is a considerable problem in lymphedema patients. As hypothesized, we found that a combined resistance exercise program using resistance exercise and CDT resulted in meaningful improvements in arm function, muscular strength, and QOL without exacerbating of edema status in breast cancer patients with arm lymphedema. Moreover, the effect of this exercise program was prominent in the severe lymphedema patients in terms of global health status and physical functioning compared with control. Our current study suggests that women with arm lymphedema can safely perform resistance exercise at moderate intensity during intensive CDT period (and after), and the resistance exercise enhances arm function and muscle strength without increase in arm volume.

Clinical experience indicates that women with arm lymphedema are very apprehensive about lifting heavier weights and are recommended to avoid vigorous, repetitive, or excessive upper body exercise to prevent

TABLE 4
Mean Values Obtained for QOL, DASH, Arm Volume, and Muscular Strength at Post-Treatment

Classification	Intervention (n = 22)	Control (n = 22)	*p*
EORTC QLQ-C30[a]			
Global health status/QOL	61.7±18.8	62.4±22.5	0.908
Functional Scales			
Physical functioning	78.6±16.5	70.5±21.7	0.170
Role functioning	63.6±24.7	67.0±27.5	0.668
Emotional functioning	64.3±23.6	75.0±25.9	0.156
Cognitive functioning	82.3±17.5	71.6±25.0	0.109
Social functioning	61.2±28.7	73.0±25.7	0.159
Symptom Scales			
Fatigue	24.0±23.4	21.0±23.4	0.675
Pain	30.7±28.2	29.1±30.4	0.862
Dyspnea	24.0±27.4	30.7±28.2	0.850
EORTC QLQ-BR23[b]			
Functional Scales			
Body image	54.9±28.1	52.1±20.6	0.712
Sexual functioning	74.5±29.2	84.6±25.3	0.224
Symptom Scales			
Breast symptoms	15.6±12.7	16.3±22.1	0.907
Arm symptoms	33.4±24.1	26.8±19.5	0.329
Sum of Muscular strength (N)	39.5±8.8	73.6±5.9	0.070
DASH (Score)[c]	23.5±14.5	29.9±18.5	0.001
Arm volume (mL)	1947.2±372.8	1993.6±254.8	0.633

[a]Quality of life questionnaire-cancer
[b]Quality of life questionnaire-breast
[c]Disabilities of Arm, Shoulder, and Hand

lymphedema exacerbation. Thus, many women with arm lymphedema complain about muscle weakness and difficulties in performing daily living activities such as cleaning or child care. This reduced activity may hinder rehabilitation and result in muscle atrophy, increased adiposity, and declining function in long term perspective.

Upper body resistance exercise is emerging as a particularly important therapy for breast cancer survivors with arm lymphedema as it supports improved clearance of lymph through the effect of the muscle pump on venous and lymphatic clearance. Moreover, increases in lean muscle mass, muscle strength, and endurance are also expected to have significantly positive effects on physical functional ability and result in an elevated maximal work capacity, meaning that everyday tasks would require less effort.

Our findings of no significant pre-post differences between the groups in arm volume provide evidence that resistance exercise performed with moderate loads is safe for women with arm lymphedema. Strengthening exercises with elastic resistance have been shown to be a feasible alternative to heavy weights in certain situations (25). The resistance bands are easily accessible in hospitals and clinics and the current findings add to an emerging body of evidence indicating that regular upper arm resistance exercise with

TABLE 5
The Changes in QOL, DASH, Arm Volume, and Muscular Strength between the Intervention and Control Groups after Treatment

		Before	After	*p*
EORTC QLQ-C30[a]				
Global health status/QOL	Intervention	44.0±21.1	61.7±18.8	0.000
	Control	51.2±18.8	62.4±22.5	0.001
Functional Scales				
Physical functioning	Intervention	70.6±15.0	78.6±16.5	0.004
	Control	66.3±19.5	70.5±21.7	0.227
Role functioning	Intervention	60.9±20.19	63.6±24.7	0.575
	Control	61.4±29.9	67.0±27.5	0.227
Emotional functioning	Intervention	60.9±20.1	64.3±23.6	0.503
	Control	61.4±29.9	75.0±25.9	0.268
Cognitive functioning	Intervention	67.8±23.5	82.3±17.5	0.003
	Control	68.3±27.6	71.6±25.0	0.410
Social functioning	Intervention	52.6±32.3	61.2±28.7	0.255
	Control	65.6±27.4	73.0±25.7	0.111
Symptom Scales				
Fatigue	Intervention	50.0±23.5	24.0±23.4	0.000
	Control	44.3±23.3	21.0±23.4	0.000
Pain	Intervention	42.8±20.9	30.7±28.2	0.049
	Control	35.5±27.7	29.1±30.4	0.172
Dyspnea	Intervention	27.7±18.6	24.0±27.4	0.736
	Control	24.7±20.2	30.7±28.2	0.879
EORTC QLQ-BR23[b]				
Functional Scales				
Body image	Intervention	42.1±34.7	54.9±28.1	0.071
	Control	46.8±26.4	52.1±20.6	0.290
Sexual functioning	Intervention	76.1±30.2	74.5±29.2	0.842
	Control	86.9±19.4	84.6±25.3	0.730
Symptom Scales				
Breast symptoms	Intervention	40.7±26.5	15.6±12.7	0.000
	Control	32.5±20.0	16.3±22.1	0.220
Arm symptoms	Intervention	48.1±27.2	33.4±24.1	0.011
	Control	52.0±21.2	26.8±19.5	0.000
Muscular strength				
Sum (N)	Intervention	71.1±6.6	73.6±5.9	0.000
	Control	70.3±8.6	69.5±8.8	0.116
DASH[c]	Intervention	34.8±18.6	23.5±14.5	0.000
	Control	30.2±18.3	29.9±18.5	0.912
Arm volume (mL)	Intervention	2083.6±422.6	1947.2±372.8	0.000
	Control	2130.6±322.0	1993.6±254.8	0.000

[a]Quality of life questionnaire-cancer; [b]Quality of life questionnaire-breast; [c]Disabilities of Arm, Shoulder, and Hand

TABLE 6
Comparison of the Changes in QOL, DASH, Arm Volume and Muscular Strength between the Intervention and Control Groups According to the Severity of Lymphedema after Treatment

		Intervention Difference	Control difference	*p*
EORTC QLQ-C30[a]				
Global health status/QOL	Mild	13.3±18.1	9.0±10.8	0.644
	Severe	24.9±15.9	9.5±9.6	0.010
Functional Scales				
Physical functioning	Mild	3.7±11.8	9.8±16.6	0.358
	Severe	11.6±11.0	-0.4±11.3	0.044
Role functioning	Mild	3.4±20.6	5.5±17.2	0.808
	Severe	4.0±27.5	2.1±26.8	0.852
Emotional functioning	Mild	-1.0±20.3	2.4±7.9	0.629
	Severe	5.6±22.5	5.5±15.6	0.992
Cognitive functioning	Mild	11.8±19.2	0.0±11.3	0.112
	Severe	16.6±21.3	6.1±23.3	0.263
Social functioning	Mild	2.2±38.8	1.6±18.6	0.965
	Severe	13.9±31.0	12.5±22.8	0.900
Symptom Scales				
Fatigue	Mild	-26.5±20.3	-18.1±12.7	0.283
	Severe	-25.6±20.0	-27.5±17.2	0.804
Pain	Mild	-21.6±32.2	-16.8±19.1	0.691
	Severe	-4.1±20.0	2.3±19.2	0.809
Dyspnea	Mild	-3.3±32.8	3.3±10.4	0.265
	Severe	-4.0±26.6	-1.2±28.7	0.810
EORTC QLQ-BR23[b]				
Functional Scales				
Body image	Mild	13.9±41.4	-4.0±13.2	0.458
	Severe	11.7±21.8	13.0±26.5	0.903
Sexual functioning	Mild	-2.0±48.2	3.4±10.7	0.824
	Severe	-1.3±28.9	-6.9±39.4	0.697
Symptom Scales				
Breast symptoms	Mild	-25.9±15.4	16.3±18.2	0.119
	Severe	-23.1±21.5	15.8±38.5	0.525
Arm symptoms	Mild	-11.3±32.2	-26.6±18.2	0.124
	Severe	-17.5±16.9	-24.0±31.5	0.538
Muscular strength				
Sum (N)	Mild	-2.2±1.4	0.1±2.3	0.010
	Severe	-2.7±1.6	0.7±2.8	0.010
DASH[c]	Mild	-9.3±8.1	-0.4±6.1	0.020
	Severe	-12.9±12.6	-0.2±17.7	0.033
Arm volume (mL)	Mild	-76.7±79.7	-50.9±36.4	0.570
	Severe	-186.0±79.3	-208.8±62.4	0.443

[a]Quality of life questionnaire-cancer; [b]Quality of life questionnaire-breast;
[c]Disabilities of Arm, Shoulder, and Hand

moderate loads is safe for women with arm lymphedema when appropriately prescribed and supervised.

Both our study groups who underwent CDT alone or the combined resistance exercise and CDT showed significant improvements in global health, fatigue, arm symptoms, and arm volume. Interestingly, the resistance exercise group achieved improvement in more items including physical and cognitive functioning, pain and breast symptoms, muscular strength, and DASH score. At post-treatment assessment, there were no differences in the final arm volume in both groups. We can conclude that resistance exercise is effective on arm function and muscular strength in lymphedema patients without an increase in arm volume. Also, our study adds value in that we found significant improvement in global health status and physical functioning in patients with severe lymphedema after resistance exercise, as this is the first study that has evaluated the effect of resistance exercise in lymphedema according to the severity of lymphedema.

Cormie et al (26) showed that upper body resistance exercise with either high or low loads does not increase the extent of swelling or the severity of symptoms in breast cancer-related lymphedema patients. Indeed, moderate- to high-intensity resistance exercise significantly improved muscle strength, muscle endurance, and QOL in women with breast cancer-related lymphedema. Ahmed et al (27) also have demonstrated that a 6-month exercise program that includes weight training improves strength without increasing lymphedema in women after breast cancer surgery that involved axillary node dissection. The intervention regimen in this latter study comprised twice weekly weight training over a period of 6 months. Lymphedema was monitored at baseline and at 6 months by measuring the circumference of each arm and via clinical diagnosis and self-reported symptoms. Schmitz et al (11) reported that slowly progressive weight lifting had no significant effect on limb swelling and resulted in a decreased incidence of exacerbations of lymphedema, reduced symptoms, and increased strength. The limitations of our current study were that it was conducted with a small sample size and had a short exercise period. Moreover, we do not have long-term follow-up data. In future studies, a larger sample and longer follow-up period are highly recommended.

CONCLUSION

This present study is the first stratified, randomized controlled trial to examine the safety of combined resistance exercise and intensive CDT prescriptions for the management of breast cancer-related lymphedema. The resistance exercise had beneficial effects on the incidence of exacerbations, severity of lymphedema symptoms, arm disabilities, and muscle strength. Furthermore, our current analysis is consistent with previous studies that exercise involving the affected limb does not initiate or exacerbate arm lymphedema. This study thus provides support for the recommendations that women with breast cancer-related lymphedema can safely perform resistance exercise of moderate intensity during the intensive CDT period regardless of severity of lymphedema.

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