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ORIGINAL ARTICLE

Aqua lymphatic therapy in women who suffer from breast cancer treatment-related lymphedema: a randomized controlled study

Dorit Tidhar · Michal Katz-Leurer

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Abstract
Background Lymphedema is an adverse effect of breast cancer surgery. Aqua lymphatic therapy (ALT) is a novel treatment for limb volume reduction.
Objective The aim of this study was to examine whether ALT is a safe method and whether there are differences in adherence, limb volume, and quality of life between women who perform only self-management treatment and women who participate as well in ALT.
Design Design of the study was single-blind randomized clinical trial.
Setting The setting was in a hydrotherapy pool, 1.2 m depth, and a temperature of 32–33°C.
Patients Forty-eight women (56±10 years), with a 12.8% lymphedema relative volume, participated in the study.
Intervention The control group was instructed to perform the self-management treatment. The study group joined a weekly session of ALT for 3 months in addition to the self-management therapy.
Measurements Adherence was assessed by a self-reported diary, limb volume by a water displacement device, quality of life by the Upper Limb Lymphedema Questionnaire (ULL27), prior to, and after the intervention period.
Results There was no episode of arm infection or aggravation in limb volume during the study period. ALT had a positive, statistically and clinically significant immediate effect on limb volume but no long-term effect was noted. The adherence rate to ALT was significantly higher than the adherence to self-management therapy. QOL improved in the study group.
Conclusion ALT was found to be a safe method, with high adherence, in treating women who suffer from mild to moderate lymphedema. A significant immediate and insignificant long-term effect on limb volume was noted.

Keywords Aqua therapy · Breast cancer · Lymphedema

D. Tidhar
Department of Physical Therapy, "Maccabi Healthcare Services", Netivot, Israel

M. Katz-Leurer (✉)
Department of Physical Therapy, School of Health Professions, Sackler Faculty of Medicine, Tel-Aviv University, Tel-Aviv 69978, Israel
e-mail: michalkz@post.tau.ac.il

Introduction

Lymphedema is a rich protein edema that may develop after breast cancer surgery which includes removal of the axillary lymph nodes. The incidence of lymphedema among women who underwent breast cancer surgery with axillary lymph node dissection ranges from 6% to 56% [1–3]. Lymphedema is usually divided into three categories according to severity: mild (up to 20% compared with the healthy arm), moderate (20–40%), and severe (above 40%) [4]. Several factors predict a higher risk for development of lymphedema after breast cancer therapy, including a greater extent of axillary surgery, more positive axillary nodes, a postoperative axillary hematoma, seroma or infection, poor shoulder mobility, the use of nodal radiation, and obesity [5–7]. For women with lymphedema, factors associated with the level of severity include current infection, obesity, and excessive hand use [8].

The common symptoms of lymphedema are swelling, discomfort, pain, heaviness, tightness, hypersensitivity, lack of sensation in the affected arm, and a decrease of general daily functions. Body image and sexual problems [4, 9, 10], as well as anxiety and depression, may also be present [10].

The common method for lymphedema treatment is complex physical therapy (CPT) [11, 12], which contains

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four complementary elements: skin care, manual lymph drainage, compression therapy, and remedial exercises. The treatment is performed in two phases: the intensive phase, in which the majority of the edema is reduced, and the maintenance phase, in which the patient performs self-therapy in order to maintain the results of the intensive treatment [13]. According to the literature, results after the intensive phase of therapy range from a 18.7% to 71.6% reduction of edema compared with the initial status of the limb [11, 12, 14].

Lymphedema cannot be cured, only controlled [4]. Women are commonly advised, even among those whose lymphedema is completely reduced, to perform self-maintenance therapy [13] and to avoid using the affected arm for heavy work or exercises, so as not to overload the lymphatic system, and in order to prevent a return to swelling [15]. Even though these recommendations are prevalent, there are only a few studies which assessed the unique contribution of the maintenance therapy components on limb volume reduction and studies that assessed the associations between performing exercises on limb volume.

Few of the studies which assessed the relationship between adherence to maintenance therapy and lymphedema were follow-up studies. In a 3-year follow-up study, it was found that an adherence of 75% and above to maintenance therapy components (defined as exercising twice a day and wearing a compression sleeve day and night) was associated with improved limb volume, while adherence of less than 75% caused aggravation of the edema [14]. Similar results were found in a 1-year follow-up study. In that study, adherence to therapy was defined as the use of a compression sleeve every day and at least three nights of low-stretch bandage wraps (which is 75% of the compression maintenance therapy protocol). Among those who adhered to the treatment, an improvement of lymphedema during follow-up was noted, while nonadherence caused aggravation of the edema [13].

Few studies assessed the safety and the efficacy of different exercises on the affected arm volume. Piller et al. found that combined arm exercise and deep breathing has an immediate positive effect on edema [16]. Other studies demonstrated that vigorous arm exercises can be performed with and without a compression sleeve without precipitating lymphedema [15, 17, 18]. Johansson et al. [19] showed that low-intensity exercises with weights increased the total volume of the arm immediately after training in the unaffected arm, as well as in the affected arm among women with breast cancer treatment-related lymphedema (BCRL), whether the exercises were performed with or without a compression sleeve. Another study assessed the influence of resistance exercises in a water environment among seven women with mild BCRL, which showed no aggravation of lymphedema immediately after the sessions [20].

Aqua lymphatic therapy (ALT) is an innovative treatment for lymphedema which targets edema reduction. Performed in a hydrotherapy pool, ALT uses the physical properties of water to enable women to perform self-massage and exercises to treat lymphedema and to maintain and even improve the volume reduction achieved during the intensive treatment phase with CPT. There is limited data published on the ALT technique, and only observational case series are available [21].

ALT is based on the anatomic principles of the lymphatic system. The viscosity of water provides resistance to body movement which promotes strengthening and improves lymphatic clearance. Since water resists movement in any plane, a variety of limb movements can be used and provides altered pressures on the skin and may improve pumping of the lymphatic vessels. The hydrostatic pressure of water gradually increases with greater depth, therefore enhancing and influencing the direction of lymphatic flow [21].

ALT is performed in a group of women with similar conditions. Each session lasts 45 min, once a week. Circumference measurements are taken at the beginning and at the end of each session in order to monitor the efficiency of ALT and to ensure that the session was safe and that no aggravation of lymphedema occurred. Edema volume is calculated and feedback charts are given to the participants every few sessions [21].

The objectives of the study were to examine whether ALT is a safe method for women who suffer from BCRL and to assess whether adding ALT to self-management care has an additional effect on adherence, upper limb volume, and quality of life measures.

Materials and methods

Design overview

As adherence to therapy was the key factor in the treatments success, the main outcome in this study was the percentage of adherence to the therapy protocol. The calculations for adequate sample size were based on the assumption of an approximately 50% adherence rate in the control group [22, 23] as compared to 85% in the study group (based on clinical experience). Based on a type 1 error=0.05 and with the power of the test as 0.8, these calculations yielded a minimum number of 20 subjects for each study group. Due to difficulties in activating three consecutive ALT groups (coordination of pool schedule and lowering the temperature of the pool for each session), the allocation ratio changed to a 1:2 ratio (study/control), which caused an increase in the study sample to 48. The actual number of subjects in each group was 16 women in the ALT group

and 32 in the control group. The intention-to-treat principle was used, and all of the subjects were asked to participate in the 3-month measurements at the end of the intervention, regardless of whether they dropped out of the program.

Between November 2005 to January 2006, 48 women who suffered from BCRL gave their informed consent and enrolled in the study. Following the baseline assessment, participants were randomly assigned to either the ALT group or the control group using the block sampling method. Each block contained six cells and the allocation ratio was two studies vs. four controls. Assignment was concealed in sequential opaque envelopes and was revealed by an independent researcher not involved in the assessment. The therapist who performed the outcome assessments was unaware of the group allocation throughout the study. However, the clinical physical therapist who administered the program and the therapist who performed the limb volume assessment at the first and the last sessions in the pool were not blinded to the group allocation.

The study was given ethics approval by the Asuta Hospital Ethics Committee and the Tel Aviv University Ethics Committee.

Setting and participants

The ALT sessions were conducted at a hydrotherapy pool in Ramat Gan, Israel. Participants in this study were recruited from the Physiotherapy Department of Maccabi Health Care Services (Fig. 1—flow chart). Included in the study were women who:

- ☐ Suffered from unilateral lymphedema due to breast cancer surgery and had undergone axillary lymph node dissection
- ☐ Had undergone or completed the intensive phase of CPT in the past and were at least 2 weeks into the self-management stage of therapy
- ☐ Received approval to participate in ALT by their physician

Excluded from the study were those who:

- ☐ Had undergone sentinel lymph node biopsy
- ☐ Had active metastatic disease

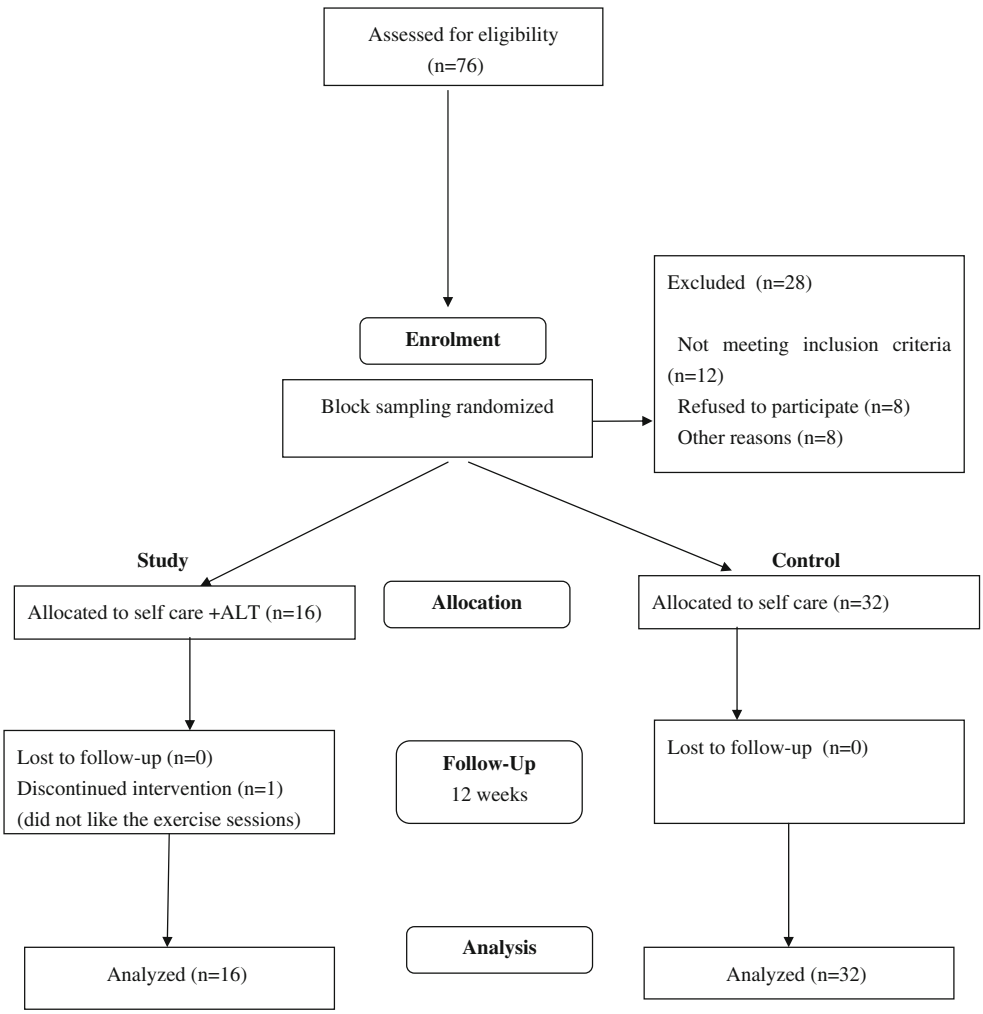

Fig. 1 Flowchart

Intervention

The study group (16 women) joined a weekly session of ALT and were advised to carry on with their self-management treatment during the rest of the week. Exercises were performed in a 1.2-m deep pool with a temperature between 32°C and 33°C [21].

The control group was instructed to continue to perform the self-management measures as usual up to the beginning of the study.

Description of the ALT method

ALT is based on the anatomic principles of the lymphatic system. The viscosity of water provides resistance to body movement. ALT is comprised of gentle exercises, which are performed in a low resistance manner. This is done by minimizing the surface of progression, for example, walking on the side, cutting the water, and use of the short lever of the arm. Hydrostatic pressure is used to protect the arm from swelling and reduces edema, the primary goal of ALT.

ALT is performed in a group setting, in which women, with similar conditions exercise together. Each session lasts 45 min, once a week. The sequence of exercise is important. First, healthy lymphotomes are activated proximally in order to clear the reservoir, by breathing exercises (Fig. 2). Second, proximal movements of chest and shoulder girdle and manual techniques of self-massage are performed. Lastly, work is performed to clear the affected lymphotomes into the healthy ones by vertical positioning of the arm in the water and performing self-massage and distal movements that involve the elbows, wrists, and fingers (see examples in Fig. 3). More specific details can be found in Tidhar et al. article [21].

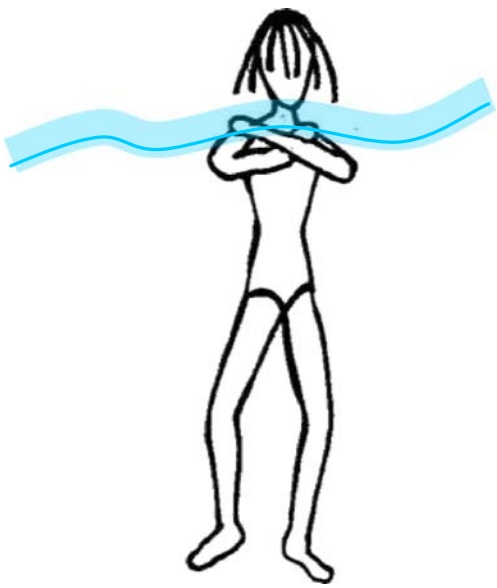

Fig. 2 Self-massage—clearing the subclavicular lymph nodes [15]

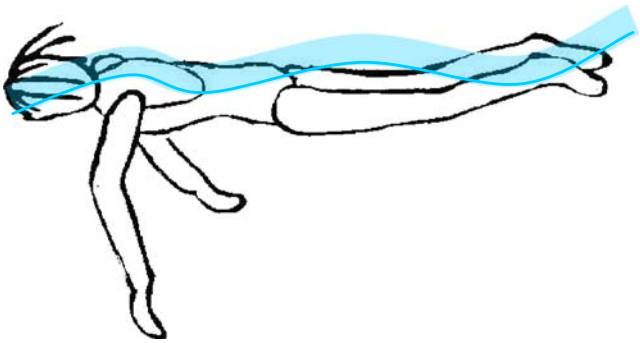

Fig. 3 The "Dog paddle": exercise—using maximum hydrostatic pressure on the hand. The direction of flow is from distal to proximal

Outcome and follow-up

Safety was assessed by an absence of related infections. Women were instructed to report any infection during the study period, and any increase of limb volume among the study group subjects was defined as an adverse event.

Adherence to treatment was assessed by using an "adherence diary". The adherence was calculated by the frequency of exercise performance per week, adherence to compression, and self-massage performance (for example, 50% adherence to exercise meant that a woman exercised once a day (which means seven out of the 14 times recommended per week)). A subject who performed more than 75% of the program was considered an adherent, based on Lasinski et al. [24]. Adherence diaries were sent by mail to the study administrator.

Limb volume was measured by water displacement which is the standard in measuring upper limb extremity volume. A woman sat on a chair, immersed her arm slowly into a container of room temperature water (~30°), and the arm was measured up to 11 cm below the axilla. This method was validated by measuring a constant object of 1,240 ml that showed a high consistency (a difference of 10 ml between ten repeated measurements) [25]. Different studies have shown that the standard error of measurement (SEM) of the upper extremity volume assessment was between 11.46 and 81.7 ml [25, 26]. The assessment using the water displacement is a reliable method with an intraclass correlation (ICC) of 0.99 [25, 26]. In a pilot study that was done prior to this study, the SEM of the limb volume using the water displacement method was found to be 40.4 ml. Intrarater reliability was high (ICC=0.99).

Edema volume was obtained by calculating the difference in volume between the arm with lymphedema and the contralateral arm.

$$\text{Edema volume(EV)} = \text{volume lymphedema arm} - \text{volume contra lateral arm.}$$

The lympedema relative volume, which expresses the severity of lymphedema [4, 8], is obtained by using the formula:

$$\text{Lymphedema relative volume (LRV)} = \frac{(\text{EV}) \times 100}{\text{Volume contra lateral arm}}.$$

Quality of life was assessed by a questionnaire that was developed by Mayrovitz et al. [27], specifically for lymphedema of the arm. The ULL27 measures current (within the last month) physical, psychological, and social withdrawal QOL. The maximal scores are 75 points for the physical dimension, 35 points for the psychological dimension, and 25 points for the social dimension. Lower scores in the ULL27 indicate a higher QOL

The questionnaire was found to be reliable and valid for breast cancer lymphedema patients. Mayrovitz et al. [27] found the ULL27 to be clinically valid. A significant difference between grades of severity of lymphedema were found for the physical ($p<0.02$) and social ($p<0.02$) dimensions which show that quality of life is lower in the severe stages of the disease. The internal consistency reliability assessed by the Cronbach's α and was found to be higher for the physical dimension (0.93, 0.86 for the psychological dimension, and 0.82 for the social dimension). A test–retest reliability found a correlation of 0.86 for the physical dimension, 0.80 for the psychological dimension, and 0.80 for the social dimension [27].

Study procedure

Prior to randomization, both groups went through an assessment that included a personal details questionnaire, measurement of body weight, and volume of two arms. All filled out a quality of life questionnaire (the ULL27 questionnaire) and received exercise and self-massage instruction booklets [11] and adherence diaries which they were asked to fill during the 3-months period of the study.

After the randomization process, the study group patients started the intervention program. The women came once a week to the pool and were measured with water displacement before and after the first and the last sessions.

At the end of the follow-up, all participants were reassessed for limb volume, weight, and quality of life.

Statistical analysis

Descriptive analysis of the demographic and medical characteristics are presented in Table 1 using frequency distribution for categorical data and mean (standard deviation, SD) for continuous variables. The quality of the randomization was examined by a t test (for continuous variables), based on unequal sample sizes with equal or unequal variance, which was determined by performing the Levene's test and a χ^2 test (for categorical variables). The distribution of outcome measures showed similar patterns as normal curve (Kolmogorov–Smirnov test for normality; limb volume measures p values ranged between 0.58 and 0.88, QOL parameters p values ranged between 0.30 and 0.45). To test the immediate effect of ALT on the volume of the lymphedema arm, a paired t test was performed.

To assess the long-term effect on lymphedema relative volume (LRV) and to assess treatment effect on QOL parameters, a repeated measures analysis of variance (ANOVA) was performed with a between-subject factor of group (study vs. control) and the within-subject factor of time (entry and postintervention measures). A Pearson correlation (r_p) was calculated to present associations between outcome measures. Results were considered statistically significant when the p value was <0.05. Data were analyzed using a SPSS-v.12 statistical package (SPSS Inc., Chicago, IL, USA) [28].

Results

Descriptive data for the study and control groups are displayed in Table 1. Forty-eight patients were followed. The mean age was 56 years (31 to 81 years). The women were on average 6.5 years postbreast cancer surgery and averaged 18 months postintensive phase of the CPT (2 weeks to 96 months). The LRV was on average 12.8%. This volume is considered mild lymphedema [4] (78% of the women had mild lymphedema). There were no statistically significant baseline differences in demographic or clinical parameters between the study groups, except for the chemotherapy and radiation characteristics which were higher in the control group, and the rate of mastectomy versus lumpectomy surgery, which was higher in the study group. Nonsignificant differences were noted in the LRV in relation to chemotherapy and radiation characteristics; for example, the mean LRV among the patients who received radiotherapy was by mean 13.6% (20.2%), while among those who did not receive radiotherapy, the average edema rate was 8.8% (10.2%; $p=0.52$).

Two women from the study group were not satisfied with the ALT sessions. They were both advised to discontinue the sessions. The first woman left after the initial therapy session, and the second woman continued until the end of the period. Nevertheless, all women were assessed at the end of the study period. None of the women suffered from any infections during the study period.

Table 2 presents the adherence rate for the components of the self-management of lymphedema care at the beginning and during the follow-up period. At entry time, 75% of the self-management treatment had not been

Table 1 Sociodemographic, lifestyle, and medical history characteristics of the participants in the study groups

Variable[a]	Study (N=16)	Control (N=32)	p value
Demographic			
Age (years) mean (SD)	56.2 (10.7)	56.5 (8.8)	0.93[b]
Education			
High school	7 (43.8)	15 (46.9)	0.28[c]
Academic	9. (56.3)	17 (53.1)	
Marital status: married	10 (62.5)	22 (68.7)	0.55[c]
Life style			
Smoking	0 (0)	2 (6.5)	0.62[c]
Physical activity	10 (62.5)	22 (68.7)	0.60[c]
Alcohol use	1 (6.3)	2 (6.5)	0.29[c]
BMI>25	13 (81.3)	24 (75.0)	0.63[c]
Medical history (breast cancer)			
Number of years since the surgery, mean (SD)	5 (7)	6 (5)	0.42[b]
Type of surgery			
Lumpectomy	5 (31.3)	22 (68.8)	0.03[c]
Mastectomy	11 (68.7)	10 (31.2)	
Number of lymph nodes excised in surgery, mean (SD)	18.0 (10.1)	16.8 (5.0)	0.60[b]
Number of affected lymph nodes, mean (SD)	1.8 (4.2)	2.0 (3.3)	0.90[b]
Adjuvant therapy: chemotherapy	9 (56.3)	26 (83.9)	0.04[c]
Radiotherapy	10 (62.5)	30 (93.8)	0.006[b]
Radiation to the Axilla mean (SD)	7 (70)	14 (46.7)	0.20[c]
Hormonal therapy	6 (37.5)	21 (65.5)	0.06[c]
Lymphedema latency (months from surgery) mean (SD)	5.5 (1.6)	5.0 (0.5)	0.23[b]
Edema volume (ml) mean (SD)	340.0 (617.4)	251.3 (368.7)	0.51[b]
RLV (%)mean (SD)	15.0 (24.5)	11.7 (15.6)	0.57[b]
Lymphedema severity			
Mild (RLV up to 20%)	13 (81.3)	24 (75.0)	0.86[c]
Moderate (RLV 20–40%)	2 (12.5)	6 (18.7)	
Severe (RLV above 40%)	1 (6.3)	2 (6.3)	

RLV relative lymphedema volume

[a] Data are reported as number (percentage) of subjects, unless otherwise indicated

[b] As determined by independent sample t tests

[c] As determined by chi-square tests

performed by any of the women. The mean adherence rate to self-management for both groups was lower than 30% at entry time and during the study period. The adherence for the ALT was 79% (ranges from 42% to 100% are not shown in the table). Eighty-six percent of the women adhered to more than 75% of the ALT sessions. This was significantly higher compared with self-management therapy and each of its components ($p<0.05$).

Only 75% of the study participants completed and returned the adherence diaries. There were no significant differences in LRV or in the initial adherence to the maintenance therapy between those who returned the diary and those who did not (data not presented).

A positive weak correlation was found between the severity of lymphedema and adherence rate in the beginning and during the study period (r_p=0.38, r_p=0.33, $p<0.05$, respectively). Garment use was positively correlated to the severity of edema in the beginning and during the study period (r_p=0.56, r_p=0.52, $p<0.05$, respectively). In the study group, a positive correlation was found between the adherence rate to ALT sessions and the severity of edema (r_p=0.51, $p<0.05$; data not presented in the table).

Table 2 Adherence to maintenance program (≥75%) at the beginning of the study and during follow-up by study groups

Self-management	Baseline			Follow-up		
	Study (N=16)	Control (N=32)	p value[a]	Study (N=12)	Control (N=24)	p value[a]
Compression garment/bandages	2 (12.5)	3 (9.3)	0.90	0 (0.0)	3 (12.5)	0.32
Special exercise	0 (0.0)	1 (3.1)	0.37	0 (0.0)	2 (8.3)	0.37
Self-massage	3 (18.8)	15 (46.9)	0.06	1 (8.3)	9 (37.5)	0.06
Total	0 (0.0)	0 (0.0)	1.00	0 (0.0)	2 (8.3)	0.37

Data are reported as number (percentage) of subjects

[a] As determined by chi-square tests

Table 3 demonstrates the average limb volume in the affected arm measured by water displacement, in the study group, before and after the first and last ALT sessions. There was a mean volume reduction of 53.5 ml after the first ALT session and a mean reduction of 98.2 ml after the last session. These differences were statistically and clinically significant (more than the SEM of 40.4 ml)

No correlation was found between initial arm edema and the reduction in the volume after those sessions (linear correlation of 0.3, $p>0.2$). No long-term effect of ALT on edema was noted. The mean LRV among the study group subjects at the end of the study was 14.7±23.9% and 11.8± 15.3% among the control group, which were similar to baseline values (Table 1; F1; 46=0.02, $p=0.87$).

Table 4 presents the mean and SDs of QOL scores at the beginning, at the end, and the changed score up to the end of the study, according to study groups. There were no differences in the mean subscores between groups at the beginning of the study. During the follow-up period, there was a significant difference in the psychological and social dimensions between groups; improvement was noted among the study group subjects (a decreased score indicates an improvement in status) as opposed to a decline among the controls.

Discussion

Safety of the program

The main purpose of this study was to assess the safety of ALT for women who suffer from BCRL. None of the women reported any infection of the arm during the study period and no worsening in limb volume was noted among the study participants immediately after an ALT session. No increase in limb volume was noted after the 3-month study period.

Erysipelas infection is a well-recognized complication of lymphedema. It is mainly caused by a β-hemolytic streptococci and rarely *Staphylococcus aureus* [4, 29]. Erysipelas is characterized by its sudden onset. Fever is usually apparent several hours before the signs appear on the skin. An erythema gradually extends on the extremity and is accompanied by pain and edem. The bacteria that causes erysipelas were not described in the literature as being present in pool water, but colonizes on the skin [30]. Women were instructed not to come to the ALT sessions if they had a skin wound, infection, cuts, or bruises.

Public warm water therapy pools are implicated as environments with a high exposure to common waterborne and airborne pathogens such as *Legionella* and *Mycobacterium* spp. Therefore, pool cleanliness is essential to avoid ear, sinuses, and respiratory infections [29–31].

The second assessed variable to determine the safety of the program was the immediate posttreatment and the long-term increase in limb volume. No worsening in limb volume was noted in the posttreatment evaluation. Nonsignificant differences in limb volume were noted between groups during the study period. The recent literature which assessed the safety of an exercise program for women who suffer from BCRL used limb volume aggravation as one of the outcome variables. It was found, as in this study, that an exercise program using gentle arm movements [16] and aquatic exercise [20] do not cause an increase in limb volume immediately after training. Two studies reported increased arm volume immediately after weight bearing training in the healthy arm, as well as in the affected arm. However, at the 24-h follow-up, volume increases had been reversed [15, 19]. Two studies examined the long-term effect of weight-bearing exercises on BCRL. They showed that a program done in a gradual manner caused no aggravation in lymphedema over 8 weeks [32] and over 6 months [17] of training.

The second aim of this study was to assess whether adding ALT to self-management care has an additional effect on adherence, upper limb volume, and quality of life measures.

Adherence to maintenance treatment and to the ALT program

The mean adherence rate to the maintenance treatment was low (28%). This rate is lower compared to previous studies. Boris et al. reported that 52% of the women had full adherence, which includes wearing a compression garment day and night and performing the exercises twice a day [14]. Ko et al. found that 87% of the women had full adherence [33] and Vignes and Porcher reported adherence of 74% for a low-stretch bandages protocol and 90% for an elastic sleeve wearing protocol [13]. Piller et al. reported 80% of the women in his study had 90% adherence for performing 10 min of exercise twice a day [16]. One explanation for the difference in adherence between trials may be related to the mean time since the intensive phase of lymphedema therapy. In this study, 17 months had passed

Table 3 Baseline and final volume of the lymphedema arm in the first and last ALT sessions in the study group

	Volume (ml)		*p* value[a]
	Postsession	Presession	
First session	2,513.5 (695.7)	2,459.2 (693.1)	0.02
Last session	2,613.9 (846.70)	2,515.2 (865.8)	<0.01

Data are reported as mean (SD)

[a] As determined by pair *t* test

Table 4 Baseline and follow-up values and changes from baseline for ULL27 measures among study groups

	Baseline			Follow-up		Change scores		
	Study (N=16)	Control (N=32)	p value[a]	Study (N=16)	Control (N=32)	Study (N=16)	Control (N=32)	p value[b]
Physical dimension	36.5 (12.4)	38.8 (15.5)	0.56	34.0 (13.8)	39.2 (15.5)	−2.5 (8.9)	0.4 (9.8)	0.39
Emotional dimension	16.7 (6.2)	16.7 (8.2)	0.35	13.2 (6.2)	17.2 (7.9)	−3.5 (6.4)	0.5 (4.4)	0.03
Social dimension	8.7 (5.6)	8.2 (3.5)	0.78	7.3 (4.3)	9.9 (5.8)	−1.4 (3.2)	1.7 (4.0)	0.01

Data are reported as mean (SD)

[a] As determined by independent t test

[b] As determined by repeated measures ANOVA (group and time effect)

since the women had finished the intensive phase, while in the previous studies, the follow-up began immediately after the intensive phase [14, 24, 33]. The relationship with the therapist, feedback received, and the therapists' instructions may help women maintain good adherence and may also help to explain the differences between the studies.

Another possible explanation may be the mild severity of lymphedema that this study population had. Women who had no functional disability may not have felt that they needed to perform self-management It has been described previously that symptoms must be perceived to interfere with life sufficiently to require and to adhere to treatment [34, 35]. Data regarding the severity of the lymphedema were not available in Lasinski and Dicken studies, but women with BCRL began the maintenance phase at the Vignes trial with a mean edema volume of 647±351 ml which is considered severe according to Ramos et al. [36] and moderate according to Mayrovitz et al. [27].

Adherence for attending the ALT sessions was significantly higher (79%) compared to the self-management adherence rate. One possible explanation for this difference may be related to the exercise setting, low frequency, and group exercise session. Ahmed et al. reported an adherence of 80% in a twice a week program of exercises in a group setting [17]. In both programs, the frequency of the sessions was low (once a week in this study and twice for Ahmed's, compared with a daily program for self-management). It has been stated before that an intervention needs to be suitable for incorporation into everyday life in order to increase adherence [34, 35]. In addition, both training programs were in a group setting, among women who suffered from the same problems, as well as the ability to share might have had a positive effect on adherence [37].

Another possible explanation may be that this therapy was new and raised hope for helping to control lymphedema [38]. The fact that the edema volume of the arms was measured before and after each session, providing weekly feedback, could be a motivating factor and a reason for the observed high adherence [21].

Limb volume

The ALT had immediate, positive, significant influence on the volume of the affected arm; however, no long-term effect was noted. Few studies have assessed the immediate influence of exercise on limb volume among women at the maintenance phase. Piller et al. showed an immediate mean reduction of 5.8% (52 ml) after performing 10 min of arm exercise combined with breathing exercises [16]. Johansson et al. demonstrated an immediate reduction of 12% (32 ml) after performing pool exercises in a water temperature of 28°C [20] that included swimming, arm exercises with hand plates to increase water resistance, and jogging with arm movements. In this study, women achieved a mean reduction of 16% (53 ml) of the volume of the affected arm, after the first ALT session, and a reduction of 29% (98.2 ml) after the last session.

Although Johansson et al. reported no effect of warm water (34°C) on exercising in the pool [20], in this study, exercises which were also performed in warm water (32–33°C) did achieve improvement in limb volume. The reason for the differences between the studies might be due to differences in exercise protocols and the slow pace of the ALT exercises which need a thermoneutral temperature. Women cannot relax and perform the exercises correctly when they are too cold. In Johansson et al., the study group performed vigorous exercises in warm water which was not thermoneutral. It seems that performing an exercise which targets a reduction in limb volume and is done in a warm temperature environment has an immediate positive influence on limb volume.

In this study, the immediate effect was examined at the first and last sessions. There is no study that examined a method of lymphedema therapy or exercises at different stages of the therapy period. In this study, there was almost twice the reduction at the last session (98 ml) than at the first session (53 ml). One possible reason for such a difference might be related to skill acquisition of new exercises and self-massage that is being performed in the

same sequence every session and became more advanced after 3 months of training [39].

No long-term effect of ALT on reduction of limb volume was observed. This might be due to the low self-management adherence during the breaks between sessions. It is possible that a higher frequency of ALT sessions is necessary to preserve the immediate results. This needs to be determined by a future study that will examine the residual effect of an ALT immediately, a few hours, and 1 day after a session.

Quality of life

The participants in this study group reported an improvement in the emotional and social dimensions of their quality of life according to the quality-of-life questionnaire (ULL27) [27]. On the other hand, the control group reported a worsening in their quality of life. The fact that the physical dimension did not change over the study period in both groups correlates to the fact that there was no change in arm edema over the study period. These findings are similar to the findings of Mondry et al., which described the same phenomenon, an improvement in quality of life after lymphedema therapy with no correlation to the amount of limb reduction [40]. It is possible that being "in treatment" alone improves emotional and social well-being. In the present study, it is also reasonable to assume that being part of a "group" contributed to the emotional and social well-being; performing exercise with women who had similar experiences created new friendships [37]. Amusing incidents that occurred during the pool sessions, warm water, and pleasant music may have contributed to mood elevation and could explain these results [37, 41].

This study has some limitations. The first limitation is that the randomization procedure did not produce two similar groups in all baseline measures assessed. Factors as breast/chest wall radiation, chemotherapy, and type of surgery were not equally distributed between study groups. Those variables have not been found to be a factor in predicting the prevalence of BCRL, or to its severity, and therefore do not influence the prognosis of therapy. Furthermore, edema volume was not associated with these factors. The second limitation is related to the combination between the initial sample size of this study and the low adherence for completing the adherence diaries (75%), which made us very careful in drawing conclusions regarding the question of whether a change in adherence occurred as a result of the intervention

Conclusion

ALT was found to be a safe method for treating women who suffered from mild to moderate arm lymphedema and were in the maintenance phase of therapy. It can be administrated in combination with other therapy methods for lymphedema.

In light of the fact that the prevalence of breast cancer is expected to increase, despite improvements in surgical methods [3], there is a need for evaluating current treatment methods for lymphedema. Assessing a suitable therapy for a woman must take into consideration not only the diagnosis of lymphedema but also the adherence to treatment, treatment effect on limb volume, the burden of treatment on the woman who suffers from lymphedema, and the burden on the health system. Further studies are needed to address the effect of ALT on limb volume among women who do not adhere to self-management and in women who suffer from severe lymphedema. A deeper understanding of the residual effect of ALT will enable us to determine the appropriate frequency of sessions for different types of population.

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ERRATUM

Aqua lymphatic therapy in women who suffer from breast cancer treatment-related lymphedema: a randomized controlled study

Dorit Tidhar · Michal Katz-Leurer

Erratum to: Support Care Cancer
DOI 10.1007/s00520-009-0669-4

Page 5 second paragraph:

"Quality of life was assessed by a questionnaire that was developed by **Mayrovitz et al.**"

On page 5 paragraph 3:

"The questionnaire was found to be reliable and valid for breast cancer lymphedema patients. **Mayrovitz et al**"

On page 8 at the end of paragraph 2:

"and moderate according to **Mayrovitz et al**. [27]."

All three references should be replaced by: **Launois et al.**

An incorrect version of Table 3 was published. The correct table is given here.

Table 3 Baseline and final volume of the lymphedema arm in the first and last ALT sessions in the study group

	Volume (ml)		*p* value[a]
	Presession	Postsession	
First session	2,513.5 (695.7)	2,459.2 (693.1)	0.02
Last session	2,613.9 (846.70)	2,515.2 (865.8)	<0.01

Data are reported as mean (SD)

[a]As determined by pair *t* test

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D. Tidhar
Department of Physical Therapy, "Maccabi Healthcare Services", Netivot, Israel

M. Katz-Leurer (✉)
Department of Physical Therapy, School of Health Professions, Sackler Faculty of Medicine, Tel-Aviv University, Tel-Aviv 69978, Israel
e-mail: michalkz@post.tau.ac.il

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