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ORIGINAL RESEARCH ARTICLE

Breast Cancer-Related Lymphedema

A Randomized Controlled Pilot and Feasibility Study

ABSTRACT

Letellier M-E, Towers A, Shimony A, Tidhar D: Breast cancer-related lymphedema: a randomized controlled pilot and feasibility study. Am J Phys Med Rehabil 2014;00:00–00.

Objective: Chronic lymphedema occurs frequently in breast cancer patients and is associated with significant morbidity and reduced quality-of-life. In this pilot study, the authors (1) addressed whether conducting a larger randomized controlled trial of aqua lymphatic therapy (ALT) would be feasible and (2) estimated the extent to which ALT combined with home-based exercise compared with home-based exercise alone would reduce arm disability in patients with breast cancer–related lymphedema.

Design: Twenty-five women with breast cancer–related lymphedema were randomized to either ALT in addition to a home land-based exercise program (ALT group; $n = 13$) or to a home land-based exercise program alone (control group; $n = 12$). The participants were evaluated before and after a 12-wk intervention period composed of weekly pool exercise sessions. Main outcome measures were arm volume, arm disability, pain, and quality-of-life.

Results: At follow-up, there was no statistical difference between the control and ALT groups in any of the outcomes, except for present pain intensity. At the end of the study period, there was no change in the lymphedematous limb volume in either group. Grip strength was improved in both groups. Only the ALT group showed a statistically significant difference with a reduction in pain intensity score and arm disability. Furthermore, quality-of-life significantly improved only in the ALT group.

Conclusions: Conducting a larger randomized controlled trial would be feasible. In comparison with the beginning of the intervention, the participants in the ALT group showed significant beneficial changes after 12 wks of treatment, whereas the control group did not improve. ALT did not make the lymphedema volume worse and therefore may serve as a safe alternative to land-based treatments of breast cancer–related lymphedema.

Key Words: Aqua Lymphatic Therapy, Lymphedema, Lymphedema Therapy, Quality-of-Life, Pain, Volume

Breast cancer–related lymphedema (BCRL) is a well-known complication of breast cancer treatment. The incidence varies widely in different reports, ranging from 13% to 63%, depending on the definition used, measurement techniques, extent of surgery, radiotherapy doses, and length of follow-up.[1] More conservative approaches, such as sentinel lymph node biopsy, may also result in lymphedema, with an incidence of 0% to 22%,[2] compared with axillary lymph node dissection, 41% to 94%.[3] A sense of arm heaviness, pain, weakness, and tightness may accompany BCRL.[4,5]

Arm pain, which may lead to inactivity, has been reported in 20%–50% of BCRL patients.[6] Pain is often described by survivors as burning, aching, constriction, scar sensitivity, discomfort, or tenderness.[7,8] Some of the factors contributing to pain may be mastectomy, axillary lymph node dissection, trauma to the tissues during the surgery, dissection of the intercostobrachial nerve, or intraoperative damage to axillary nerve pathways.[7,8] Studies that assessed the influence of combined decongestive therapy on lymphedema symptoms showed an improvement of pain after intensive treatment for the acute lymphedema phase.[9,10] This improvement was maintained for 1 yr.[9] However, it remained unclear whether exercise programs for lymphedema could reduce pain intensity.[11,12]

Shoulder and arm mobility may be impaired after treatments of breast cancer. Shoulder pain may occur as well and can aggravate arm mobility in a vicious cycle. Theoretically, aquatic exercises, as compared with land-based exercise, are useful to minimize fatigue and accompanying pain. In the pool, arm movements become buoyancy assisted (by Archimedes' principle). The buoyancy force of the water allows initiation of exercises that restore arthrokinetics, strengthens the rotator cuff muscles, and reduces the stress on painful weight-bearing joints such as the glenohumeral joint.[13,14]

In addition, BCRL can cause psychologic distress that may lead to impaired quality-of-life (QOL).[9,15,16] Psychologic morbidity seems to continue even after completion of active lymphedema treatment and is unrelated to the severity of the swollen limb.[17]

A recent systematic review suggests that slowly progressive exercise programs of varying modalities are not associated with the development or exacerbation of BCRL and can be safely pursued with proper supervision.[18] However, the data regarding the effect of exercise on symptoms and QOL are limited. Therefore, research into physical treatments and methods of self-management are of primary importance in this chronic lifelong condition.

Aqua lymphatic therapy (ALT) is a novel exercise treatment modality for lymphedema performed in a hydrotherapy pool.[19] ALT is based on the anatomic principles of the lymphatic system. It is believed that the following water properties can be used to increase the therapeutic effect of the exercise routine: (1) Buoyancy force is the upward force exerted by the water, and it can facilitate shoulder movement, which can sometimes be difficult on land; (2) The viscosity of water provides resistance to body movement, thus promoting strengthening and improving lymphatic clearance; and (3) The hydrostatic pressure of water will gradually increase with greater depth, which will improve lymphatic flow and influence its direction.[20] A recent randomized study on ALT demonstrated an improvement in QOL during a 3-mo intervention period compared with a control group but did not examine the effect of ALT on strength, pain, and disability.[20]

The present randomized controlled pilot study had two aims: (1) to address whether conducting a larger randomized controlled trial assessing the effectiveness of ALT would be feasible and (2) to estimate the extent to which an ALT program combined with a home-based exercise program, compared with a home-based exercise program alone, had an impact on arm disability, pain, strength, and QOL in women with BCRL.

METHODS

Study Design and Randomization

This was a single-blind randomized controlled pilot study conducted between January and April 2007 in which women were randomly allocated to one of two treatment groups: ALT combined with a home land-based exercise program (ALT group) or to a home land-based exercise program alone (control group). The participants were stratified into two groups according to the degree of volume difference between limbs, measured by water displacement volumetry (<25% interlimb difference and ≥25% interlimb difference, with 25% volume difference being the estimated median for these subjects), and then randomly allocated using a block randomization scheme. Assessment before and after a 12-wk intervention period was done by an evaluator who was blinded to the treatment allocation. The study was approved by the Research Ethics Board of the McGill University Health Centre, and informed consent was obtained from all study participants.

Participants

Patients were included in the study if they were (1) in remission from stage I or II breast cancer and had unilateral chronic arm lymphedema of any degree or duration, (2) at least 2 mos after any radiation therapy or chemotherapy, (3) at least 6 mos after surgery, and (4) wearing a well-fitted compression garment. Participants had to have the following lymphedema characteristics: a difference of 200 ml or more between the arms[21,22] or difference in limb girth of at least 2 cm at any standard measurement point[23] or a volume difference of 10%.[24] They also had to be at least 1 mo after any manual lymphatic drainage or intensive treatment with combined decongestive therapy to eliminate potential carryover effects of previous intensive treatment.

Subjects were excluded if they (1) could not be fitted with a compression garment because of severe lymphedema; (2) had a history of congestive heart failure, angina, or moderate-to-severe lung disease; (3) had a medical contraindication to water-based exercise[25]; or (4) had aversion to water-based exercise.

Participants were recruited from the Lymphedema Clinic of the McGill University Health Centre and from a private physiotherapy clinic offering lymphedema care (Physio Extra). The lymphedema clinic provided a list of 160 women with BCRL. The private clinic provided a list (n = 200) of women with lymphedema, with no indication of whether the lymphedema was associated with breast cancer or with another malignancy. Each woman was sent a letter by mail with a brief explanation of the research project and the inclusion and exclusion criteria. To learn more about the study and/or if they were interested in participating, they were asked to contact the research coordinator. Only subjects who contacted the study coordinator were further screened for potential enrollment in the study. Finally, after a baseline assessment, 25 participants were randomly assigned to either the ALT group (n = 13) or the control group (n = 12) (Fig. 1).

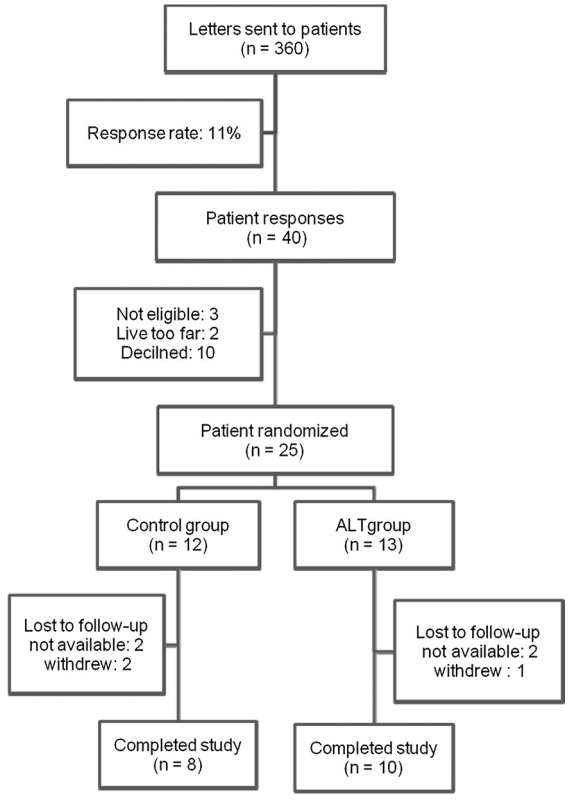

FIGURE 1 *Study flow chart.*

Interventions

Control Group

All subjects were wearing a compression sleeve of 20–30 or 30–40 mm Hg before their participation and were asked to wear it on a regular and daily basis, particularly during exercise, if they were not wearing it regularly. The participants received the DVD "Fluid Motion—Exercises for Lymphedema" by Elaine Hanson.[26] This DVD is based on the Casley-Smith remedial exercise and lymphedema therapy method.[27] The participants were asked to do the exercises in the section for arm-related lymphedema, which consists of three parts: (1) self-massage and exercises for range of motion, (2) corrective exercises, and (3) strengthening exercises. The subjects were encouraged to perform at least 25–30 mins of the DVD exercises daily. To track daily activity and number of hours of compression sleeve wear daily, the women were asked to make a diary entry on a daily basis.

ALT Group

In addition to the land-based exercise intervention above, the participants received 60 mins of ALT weekly for 12 consecutive weeks. The ALT method has been previously described elsewhere.[19] In brief, ALT is an innovative method for treating lymphedema, performed in a pool, aiming to maintain or improve the volume reduction achieved during the intensive treatment phase by combined decongestive therapy. ALT is based on the Casley-Smith remedial exercises principles.[27] Sessions were given in a warm shallow pool with a depth of 1.2–1.4 m (4–4.5 ft) and at a water temperature of 31°C to 33 °C (88°F to 91.5°F). Women were not allowed in the pool if they had an active skin infection. A handout of the water exercise sequence was given. The participants were encouraged to complete additional unsupervised weekly sessions and to perform at least 25–30 mins of the DVD exercise on the other days of the week and/or any other type of exercise.

The ALT sessions were given by three qualified therapists who had followed the 54 hrs of "Tidhar Method" training. The therapists learned a specific sequence of exercises to perform and were asked to follow it strictly to ensure good reliability of the intervention. To attend their ALT session, the participants went to the therapy location that was most convenient to their home or place of work.

Outcome Measures

Lymphedema volume was assessed by (1) water displacement (Jamar Deluxe Arm Volumeter) and (2) circumferential measurements. Water displacement has been reported to be reliable, with an intraclass correlation coefficient of 0.99.[28,29] Edema volume was obtained by calculating the difference in volume between the arm with lymphedema and the contralateral arm. The relative lymphedema volume (percentage), which expresses the severity of lymphedema, was calculated as the percentage of the healthy arm [$(\text{Volume}_{\text{affected arm}} - \text{Volume}_{\text{control arm}}) \times 100/\text{Volume}_{\text{control arm}}$]. For the circumferential measurements, a flexible measuring tape was used. Circumferences of the limb were taken in six predetermined points (mid hand, wrist, and every 10 cm from the wrist up to 40 cm). Volume was calculated from circumference using the truncated cone method.[28] This method is highly correlated with the water displacement method (intraclass correlation coefficient, $\geq$0.95) but is not interchangeable with it.[27–31] The standard error measurement of volume calculation measured by a measuring tape ranges from 10 ml (Karges et al.[30]) to 65 ml (Taylor et al.[31]).

Grip strength was evaluated by a Baseline hydraulic hand dynamometer, which has high reliability (intraclass correlation coefficient, 0.85–0.98), as reported by Segura-Orti and Martinez-Olmos.[32] In different populations, minimal clinically important difference (MCID) values for grip strength have been determined to be between 4.3 kg and 6.2 kg.[32,33]

Pain was assessed by the short-form McGill Pain Questionnaire (MPQ).[34] The short form is highly correlated with the long form of the MPQ and is a valid measure for chronic cancer pain over time.[34] There are three parts to the questionnaire: 15 word descriptors that categorize the sensory (11 first words) and affective (4 last words) dimensions of pain and give two scores. There are also two measurements of pain intensity: a present pain intensity (PPI) scale and a visual analog scale.[34] The combination of those four subscales gives a possible total score of 60, in which higher scores indicate greater pain.[34] Grafton et al.[35] calculated the standard error measurement for the total score of the MPQ to be 1.87. The sensory, affective, visual analog scale, and PPI components all demonstrated the expected smaller standard error measurements: 1.64, 1.01, 0.52, and 0.51, respectively.[35] The coefficients of repeatability for the total score, sensory, affective, visual analog scale, and PPI components were 5.2, 4.5, 2.8, 1.4 cm, and 1.4, respectively.[35]

Upper extremity function was measured by using the Disabilities of the Arm, Shoulder and Hand questionnaire. This tool has good psychometric properties, with test-retest intraclass correlation coefficients between 0.92 and 0.96 and with good validity with the Short-Form Health Survey (SF-36), Constant-Murley Shoulder Score, and other upper extremity outcome measures.[36,37] The scores are expressed in a range of 0–100 (a higher score indicating a worse condition). A 10-point difference in scores may be considered as the minimal important change for patients who have undergone surgery for upper extremity musculoskeletal disorders.[38]

QOL was assessed by the Functional Assessment of Cancer Therapy–Breast Cancer (FACT-B version 4).[39] This questionnaire consists of 36 items comprising five well-established subscales: physical, social/family, emotional, and functional well-being, and a 9-item subscale of additional concerns of women with breast cancer, with an additional module of specific questions on lymphedema symptoms. This new scale showed excellent psychometric properties, with internal consistency of 0.62–0.88 and test-retest correlation of 0.97.[39] According to Eton et al.,[40] the MCID is 7–8 points.

Adherence to the ALT session was calculated by the number of times a woman attended the ALT session of the 12 sessions that were offered. All therapists were asked to note attendance at the classes.

Statistical Analysis

Frequency distribution of participant characteristics was summarized. Continuous variables were compared using the independent or paired *t* test where appropriate (to compare between the two groups or changes within each group, respectively) and were described as mean (standard deviation). Nonparametric tests were performed in the eventuality of nonnormally distributed data (Mann-Whitney *U* test to compare the changes between groups and Wilcoxon's test to compare before and after the intervention). Categorical variables were compared using the χ^2 or Fisher's exact test where appropriate and were described as proportions. Effect sizes for the changes from baseline for each group were calculated using the Cohen effect size test. An effect size is considered small when it is equal to 0.20,

moderate at 0.5, and large at 0.8.[41] All results were analyzed on an intention-to-treat basis. Each participant was analyzed within her allocated group, regardless of whether she respected her assigned group.[42] In addition, missing data are addressed with single imputation.[42] A P value of less than 0.05 was considered to be statistically significant. Data were analyzed using the Statistical Package for the Social Sciences 21 (Statistical Package for the Social Sciences Inc, Chicago, IL).

RESULTS

The baseline characteristics of the participants are shown in Table 1. The ALT and the control group were well matched in the randomization process except that, after surgery, lymphedema appeared earlier in the control group compared with the ALT group. However, the ALT group had been living longer with the lymphedema. All participants were recruited during their maintenance phase. Two weeks before study completion, the research coordinator called the participants to schedule the follow-up assessment. At this telephone call, four women in the control group and three women in the ALT group withdrew from the study or said that they were not able to commit for the follow-up appointment. Adherence to the ALT session was good, considering that it was winter in Montreal (Quebec, Canada). The median number of ALT sessions attended was 10 sessions: eight participants (62%) attended 9 sessions or more and ten patients (77%) attended 6 sessions or more of 12 (ranging from 0 to 12 sessions). Only 13 participants (52%) returned their diary fully completed; 20% had filled only the first or the second week, and none of the persons who withdrew returned their diary.

Study outcomes are summarized in Table 2. Pain is the only outcome that was not normally distributed; therefore, nonparametric tests were performed for that outcome. Except for PPI, no statistical significance was found between the two groups during the study period for all outcomes (P value ranging from 0.09 to 0.48). Therefore, only within-group comparisons are presented. At the end of the study period, there was no significant change in the lymphedematous limb volume, as expressed by the percentage of relative lymphedema volume, in both groups; volume measured by water displacement; and arm circumferences. Compared with baseline measurements, both groups had a significant improvement in hand-grip strength in both hands. The effect size was large in both groups (ALT, 1.57 and 1.06, greater than control, 0.92 and

TABLE 1 Baseline characteristics

Characteristics	Control (n = 12)	ALT (n = 13)	P
Age, mean (SD), yrs	53.4 (9.35)	56.4 (9.76)	0.89
BMI, mean (SD)	26 (4.3)	25.7 (3.2)	0.78
Affected side, n (%)			
Left	5 (41.6)	5 (38.4)	1
Right	7 (58.3)	8 (61.5)	
Type of breast surgery, n (%)			
Lumpectomy	7 (58.3)	9 (69.2)	0.69
Mastectomy	5 (41.6)	4 (30.7)	
Type of axillary surgery			
ALND	9	12	0.32
SLNB	0	0	
Missing	3	1	
Lymph nodes positive for cancer			
0	5	5	0.70
1–5	1	4	
6–10	0	1	
≥11	3	2	
Treatment, n (%)			
Chemotherapy	7 (58.3)	10 (76.9)	1
Radiation therapy	11 (91.6)	13 (100)	
Onset of lymphedema after surgery, mean (SD), yrs	0.52 (0.34)	3.84 (5.4)	<0.001
<2 yrs, n (%)	12 (100)	6 (46.1)	
≥ 2 yrs, n (%)	0 (0)	7 (53.8)	
Time living with lymphedema, mean (SD), yrs	3.19 (3.9)	3.84 (1.7)	0.01
<2 yrs, n (%)	5 (41.6)	1 (7.6)	
≥2 yrs, n (%)	7 (58.3)	12 (92.3)	

ALND, axillary lymph node dissection; BMI, body mass index; SLNB, sentinel lymph node biopsy.

TABLE 2 Results before and after intervention

	Control			ALT		
	Baseline (n = 12)	After Intervention (n = 8)	P	Baseline (n = 13)	After Intervention (n = 10)	P
%RLV by measuring tape, mean (SD)	14 (9)	13.2 (10.7)	0.625	19.1 (9.3)	15.7 (10)	0.120
ES		−0.25			−0.6	
%RLV by water displacement, mean (SD)	17.1 (9.1)	16.7 (10.1)	0.908	20 (10)	18.9 (11.3)	0.3
ES		−0.05			−0.1	
Grip strength healthy arm, mean (SD) kg	25.3 (4.4)	27.4 (4.7)	0.001	25.5 (4.0)	28.7 (4.0)	0.001
ES		0.92			1.57	
Grip strength affected arm	24.3 (9.3)	27.4 (8.3)	0.008	23.2 (6.4)	27.3 (5.8)	0.008
ES		0.85			1.06	
DASH, mean (SD)	28.6 (21.4)	22.5 (22.9)	0.385	29.4 (14.8)	20.4 (12.8)	0.016
ES		−0.33			−0.75	
FACT-B, mean (SD)	110.3 (12.3)	116.8 (12.6)	0.207	100.3 (17.9)	106.1 (19.5)	0.021
ES		0.49			0.72	
PPI[a] (min-max)	0.00 (0−2)	1 (0−1)	0.655	1 (0−3)	0.5 (0−1)	0.025
ES		0.16			−0.7	

[a]Nonparametric analysis Wilcoxon's signed-rank test: median (minimum to maximum).

DASH, Disabilities of the Arm, Shoulder and Hand; ES, effect size; RLV, relative lymphedema volume.

0.85). Arm disability, as measured by the Disabilities of the Arm, Shoulder and Hand questionnaire, significantly diminished only in the ALT group, meaning that their arm dysfunction reduced (mean difference of −9 points, P = 0.016). Effect size was −0.75 in the ALT group and −0.33 in the control group. QOL, as measured by FACT-B questionnaire, significantly improved only in the ALT group by 5.8 points, in which higher results indicate a greater QOL. For the FACT-B, effect size was 0.49 in the control group and 0.72 in the ALT group. Overall, the total short-form MPQ pain score remained unchanged in both groups at the end of the study. All participants except one reported experiencing pain to some degree, both at baseline and at the follow-up assessment. However, the ALT group showed a significant reduction in the PPI score after the 12-wk intervention, from a median of 1 to 0.5, and after intervention, with an effect size of −0.7 for the ALT group and 0.16 for the control group. No change was noticed in the PPI score for the control group. There was a statistically significant difference between groups after intervention for the PPI measure (P = 0.04), with an effect size of −0.5.

DISCUSSION

The primary aim of this pilot study was to address whether conducting a larger randomized controlled trial would be feasible. With 62% of the participants attending nine or more classes, the authors do believe that it would be possible. However, there is room for improvement on this study's recruitment methods. Of 360 letters sent, only 11% of women responded. Ways to improve recruitment in future might be (1) to stress that participants will increase their awareness of their lymphedema management[43]; (2) to recruit when the patient is attending a clinic appointment; and (3) to make a follow-up telephone call 1 wk after sending invitation letters, to answer questions and address the eligibility of the potential participants. Finally, the authors think that the time of the year made a difference in this study's response rate. For further research, particularly if conducted in areas that have cold winters, seasons need to be taken into consideration. The authors assume that they would have obtained greater participation if the pilot study had been conducted in any season other than winter.

The secondary aim of this study was to estimate the extent to which an ALT program combined with a home-based exercise intervention, compared with a home-based exercise program alone, has an impact on arm disability and QOL in BCRL patients. The women in the study had experienced chronic BCRL for several years, and they were in their maintenance phase. The authors wondered whether an intervention, such as ALT, could influence pain, disability, and QOL in the chronic stage of lymphedema. This

study suggests that, although arm volume did not change significantly over time, an addition of ALT to a home exercise program may improve arm disability and QOL and decreases the intensity of pain after 12 wks of treatment and with no adverse effects on arm volume.

It needs to be acknowledged that the authors did not ask the participants about their previous level of activity before entering the study. Therefore, a participant might have exercised more than usual because she was involved in research, which could have influenced this study's results. Because of missing data from the self-reported diaries, it is impossible to draw conclusions on level of activity or the number of hours of compression sleeve wear daily. However, the authors are certain about the adherence to the ALT session because attendance to the session was taken by the therapists. With this in mind, the findings of this study suggest that, although arm volume did not change significantly over time, an addition of ALT to a home exercise program improves arm disability and QOL and decreases the intensity of pain after 12 wks of treatment. Furthermore, the ALT group has shown a large effect size in these outcomes.

Hayes et al.[44] reported that the symptom of weakness was present twice more often in women with BCRL as compared with breast cancer survivors without lymphedema. Arm weakness after breast cancer surgery may be explained by reduced nerve impulses to the muscles, as a result of nerve entrapment after axillary surgery and irradiation.[45] In this study's sample, all participants had an axillary lymph node dissection followed by radiation therapy (except for one participant who did not have radiation). The findings of this study suggest that hand-grip strength improved similarly in both groups. A reduction in the affected arm volume is unlikely to explain this improvement because there was no change in swelling after 12 wks of treatment. However, both groups were involved in low-intensity exercise programs, which might give enough stimuli to cause an increase in hand-grip strength.

In this study, pain was examined by the short-form MPQ questionnaire. An improvement was noticed in PPI score in the ALT group only, with an effect size of -0.7. Therefore, the results of this study are in agreement with findings of pain reduction in other patient populations undergoing aquatic-based therapy.[46,47]

Disability caused by upper extremity impairments are frequently found in women after treatment of breast cancer. Moreover, women with lymphedema have greater impairment and limitation in activities than women without lymphedema.[48] To the authors' knowledge, only one study assessed the influence of exercise on lymphedematous arm disability using the Disabilities of the Arm, Shoulder and Hand questionnaire.[49] The authors reported a significant mean score reduction of 2 points after their pole-walking intervention. The results of this study also suggest that arm disability improved significantly, with a greater mean score change in the ALT group and with a greater mean score reduction of 9 points (almost reaching the MCID of 10 points), whereas no significant change was noted in the control group, with a mean score reduction of 6.1. As discussed above, this improvement could be partially explained by the pain reduction and the increase in hand-grip strength.

BCRL has an important psychosocial impact. It may impair QOL, cause depression, and have a negative impact on domestic and social activities.[12,18] Importantly, recent data have suggested that various land-based and aquatic-based exercise programs can improve the QOL of patients with BCRL.[20,28,50] The results of this study are consistent with these studies because it was shown that patients in the ALT group, but not in the control group, improved their QOL (as measured by the FACT-B questionnaire). Notably, this QOL improvement occurred in the ALT group even though there was no change noted in volume at the end of the 12-wk intervention. The reasons for this may be that ALT is done in a group setting with women who experience similar problems, in a soothing environment. The ALT exercises are gentle with a self-massage and participants massage components. Each one of the abovementioned elements can potentially improve QOL.

This study is subject to several limitations. First, the sample size was small, and the general reservations pertaining to generalizability and potential confounding factors in such a small-sized randomized study should be acknowledged. Significant statistical differences were obtained; however, none of the outcomes reached the MCID found in other disorders.[32,35,38,40] To the authors' knowledge, no studies so far have established the MCID for lymphedema. This fact contributes as well to the limited power of the study: this study might have been underpowered to find a statistical significance. Finally, this study lacked information on self-management practices by the study participants such as adherence to wearing their compression garment and performance of home land-based exercises because only 52% of the participants fully completed their diary and the questions were not formally addressed at the follow-up assessment. That data could have helped

the authors to examine a possible association between adherence to self-management practice and the outcome measures.

Despite these limitations, the authors believe that ALT may serve as a safe alternative to land-based treatments of BCRL. Compared with the control group, the ALT group had less pain and arm disability, increased hand-grip strength, and improved QOL after a 12-wk intervention. Further studies on exercise interventions, such as ALT, will help to develop effective rehabilitation programs that will reduce the burden of suffering for those who have developed chronic lymphedema as a complication of cancer treatment.

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