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THE EFFECT OF GENTLE ARM EXERCISE AND DEEP BREATHING ON SECONDARY ARM LYMPHEDEMA

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ABSTRACT

The aim of this study was to explore the benefits of gentle arm exercise combined with deep breathing for secondary arm lymphedema. 38 women participated in 10 minutes of standardized arm exercise and deep breathing and were measured every 10 minutes for 1 hour, then 24 hours and 1 week post regime. A smaller cohort of 24 women continued the 10 minute exercise regime morning and evening for 1 month, with measurements being repeated at the end of this time. Directly after performing the regime, there was a reduction in arm volume of 52 mls (5.8%), with the reduction being sustained at 30 minutes (50 mls, 5.3%). Even though participants were told not to further do the exercise, at 24 hours the volume reduction was 46 mls (4.3%) and at 1 week, 33 mls (3.5%). At the one month follow-up, the reduction was 101mls (9.0%). All reductions were statistically significant. Reported arm heaviness and tightness also statistically significantly decreased directly after the regime with the reduction in tightness being sustained at 24 hours. The reduction in heaviness was sustained at 24 hours, 1week, and even one month after the program. Perceived limb size was significantly reduced at 1 week and at the 1 month follow-up. There was also a significant improvement in the anterior thorax tonometry reading at the 1 month follow-up.

This study indicates that combined arm exercise and deep breathing is an easy to perform and implement regime which significantly reduces arm volume and subjective symptoms both initially after treatment and when performed over a 1 month period.

Breast cancer and its subsequent treatment is distressing, with the treatment often having a significant impact on the woman's quality of life (1,2). Unfortunately the problems do not always end at the cessation of treatment, with an estimated 15-30% (3) of women going on to develop the unwelcome and often unexpected condition of lymphedema.

Secondary lymphedema occurs when there is a disruption to lymphatic drainage through lymph node removal, lymphatic vessel ligation or narrowing. This results in an inadequate drainage of fluids and waste products from the extracellular space, with subsequent excess fluid accumulation in the tissues and sometimes poor oxygenation. This dysfunction manifests as a swollen and sometimes deformed limb with associated sensations of pain, tightness, heaviness, pins and needles, burning and skin dryness. The symptoms and morbidity of this condition also can have a detrimental affect on the person's quality of life, with depression, domestic and social dysfunction being reported (4).

Secondary lymphedema is chronic in nature and without some form of intervention will generally worsen over time (5,6); therefore, women with this condition need to be vigilant in limb maintenance. Treatments that aim to improve lymphatic drainage do exist, but the majority of them are labor and cost intensive and administered by allied health professionals. Currently, there are few easy to implement self management regimes which help women to have control over their limb. Compression garments may be effective in preventing fluid accumulation, but women often complain that they are difficult to put on, unsightly and uncomfortable to wear. The use of exercise regimes is promising, but poorly evidenced (7), and their efficacy remains relatively unknown. However, exercise is an easy and potentially effective therapy for lymphedema.

This study aimed to investigate the benefits of gentle arm exercise in combination with deep breathing for post-mastectomy lymphedema. It is well established that lymph propulsion and clearance is increased by varying total tissue pressure (8) and that one of the most effective ways of varying tissue pressure is through musculoskeletal movement (9). Pressure differentials created by the diaphragm are also shown to influence lymph flow, helping to propel lymph centrally for drainage into the thoracic lymphatic ducts (10). Therefore, it was postulated that gentle arm exercise and deep diaphragmatic breathing would influence lymphatic drainage from the affected limb and in comparison with a control group, would reduce arm volume and improve how the arm felt to the sufferer.

METHODS

Before trial commencement, informed consent was obtained from each participant and the study was given ethics approval by the Flinders Medical Centre Clinical Research Ethics Committee, Adelaide, Australia.

This study involved an experimental group which performed the initial arm exercise and deep breathing regime and a smaller number who continued the regime over a 1 month period. Another group which received no intervention over a 1 month period and who had previously had measurements performed before and at the end of the 1 month period were used as a comparison control group.

Participants in both groups were recruited through the Flinders Medical Centre Lymphedema Assessment Clinic. Inclusion criteria included women who had established (duration > 0.5 years) unilateral secondary arm lymphedema related to previous breast cancer treatment (surgery ± radiotherapy ± chemotherapy), and a volume difference of ≥ 200 mls (as determined by perometry). Those who had underlying primary lymphedema, recurrent cancer, cellulitis or had received treatment (i.e., massage) in the last month were excluded from the trial.

Thirty eight women participated in the initial 10 minute regime of combined arm exercise and deep breathing. The exercise begins with the hands pointing into the sternum. The arms are then slowly opened and moved outwards until they reach full extension while the person takes in a deep breath. When the arms reach full extension, all the arm muscles are tightened and the breath held. The person then relaxes the arm muscles, moves the arms back towards the starting position while breathing out (*Fig. 1*). Each participant performed 5 exercises combined with deep breathing followed by a 1 minute rest, and undertook 5 x 5 cycles of exercise + breathing over the 10 minute period (or 25 exercises in total). Participants were measured immediately prior to the regime, directly after the regime, and then every 10 minutes for 1 hour, then at 24 hours and 1 week post exercise.

After the 1 week follow up, a cohort of 24 women continued the 10 minute exercise regime morning and evening for 1 month, with measurements being repeated after this

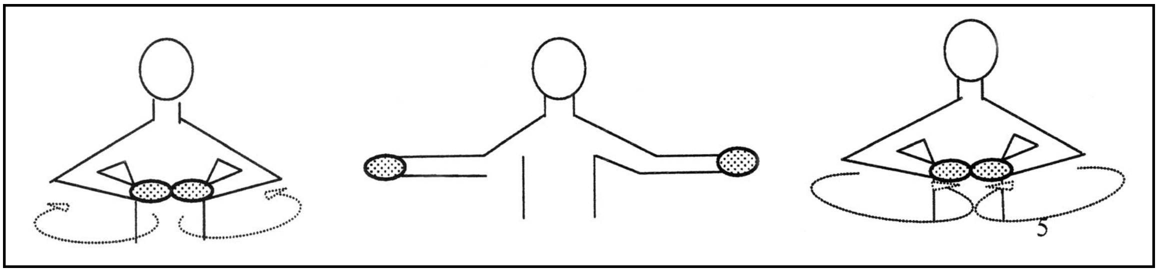


Fig. 1. Diagrammatic presentation of the combined exercise and deep breathing program. a) Starting position with fingers pointed at sternum: begins by taking a deep breath in while moving the arms slowly and gently outwards. b) When the arms reach full extension, the breath is held. All the arm muscles are then tightened. c) The arm muscles are relaxed and the arms move back to the starting position while the breath is exhaled.

time period. Participants were required to fill in a log book which recorded how many times they performed the regime over the month so compliance could be monitored. A group of women (n = 28) who had received no intervention and who had previously been monitored over a 1 month period were used as a comparison control group.

Measurements

Both groups underwent the following measurements:

Perometry

The perometer (Pero-systems®, Germany) is a previously validated (11,12) volume measuring system that is based upon a square measuring frame that contains rows of infra-red light emitting diodes on two sides and rows of corresponding sensors on the opposite two sides. The participant sits at one end with the hand resting centrally on an adjustable support. The frame is then moved along the length of the arm from the tip of the index finger to the axilla. The limb casts shadows in two planes and using the cross-sectional information obtained, a computer software program builds up a whole arm volume and circumferential picture (at 4 mm intervals).

Bioimpedance

Body bioimpedance was measured in this clinical trial with an InBody 3.0® system (Biospace Ltd®, Korea). The Inbody 3.0® is a multi-frequency body and segmental analyzer (5kHz - 500kHz) where the participant stands erect on electrode footplates and holds electrodes in the hands, resulting in eight electrode contact sites. This helps to eliminate discrepancies in electrode placement which can occur with the traditional 4 electrode systems and therefore enhances the reproducibility and accuracy of the measurements. The multi-frequency technique employed quantifies total fluids (both intracellular and extracellular) in the extremities and the trunk separately, distinguishing the gain or loss of fluid from fat and muscle (13). Previous studies have validated bioimpedance as a technique for measuring extracellular fluids in lymphedema patients (14,15).

Tonometry

Tonometry measures tissue resistance to pressure, giving an indication of the compliance of the dermis and extent of fibrotic induration (16) in the forearm, upper arm and anterior thorax lymphatic territories. The tonometer (Flinders Medical Centre Biomedical Engineering, Australia) consists of a central plunger (1 cm diameter) weighted to a mechanical load of 275.28 gms/cm^2, operating through a footplate that rests on the surrounding skin and applies a load of 12.2 gms/cm^2. Thus, the plunger applies a differential pressure of 263 gms/cm^2, and the degree of penetration of the plunger (arbitrary units) is measured by a micrometer on a linear scale.

Subjective measurements

A questionnaire was administered which assessed the participants' subjective arm symptoms, including pain, heaviness, tightness, pins and needles, burning sensations and perceived arm size. Participants were asked to rate their symptoms on a 0-10 scale as used in the previously validated (17,18) McGill Quality of Life Questionnaire, where zero equated to no symptoms and 10 was rated as the worst imaginable symptoms.

Analysis

All data were analyzed using SPPS (version 11.5). As lymphedema arm volume was not normally distributed at baseline, two related samples non-parametric Wilcoxon tests (Monte Carlo 99%) were used to analyze the change in arm volume. Results are presented as median values with the 25th and 75th percentiles, or as means and standard errors. Subjective symptoms were analyzed using the student paired sample t-test where $p < 0.05$ is statistically significant. The correlation between those who responded directly after the exercise and those who responded after one month was determined using Pearson correlation coefficient.

Lymphedema volume was calculated at each time point according to the following calculation (19):

Actual edema at time$_{(x)}$ = lymphedema arm volume at time$_{(x)}$ – normal arm volume at time$_{(x)}$

The percentage change in actual edema volume was then calculated as follows:

$$\%\text{ edema change at time}_{(2)} = \frac{\text{actual edema at time}_{(1)} - \text{actual edema at time}_{(2)} \times 100}{\text{actual edema at time}_{(1)}}$$

RESULTS

Originally 40 women were recruited in to the exercise group, but two were subsequently removed from analysis due to one not having a significant lymphedema (volume < 200mls) and the other having extremely fluctuating volumes (beyond what would normally be expected). The remaining thirty eight women were aged 37-77 yrs (mean 61 ≤ 9.5 yrs) with unilateral post mastectomy arm lymphedema. Twenty were treated by a total mastectomy and 18 by a partial mastectomy. All women had undergone axillary lymph node clearance, with 76% receiving adjunct radiotherapy. Lymphedema duration varied, with 48% having it for 1-5 yrs, 21% for 6-10 yrs, and 31% for greater then 10 yrs. *Table 1* presents the demographic details of the women who were involved in the 1 month exercise and deep breathing program and the women in the comparison control group.

Arm Volume

Directly after performing the 10 minute exercise, there was a median reduction in arm volume of 52 mls ($p = 0.004$; *Fig. 2*). This represents a percentage reduction in lymphedema of 5.8%. A reduction was sustained at the 30 minute point (50 mls, $p = 0.006$, 5.3%) but after this time the fluid gradually returned and by 60 minutes the median volume had returned to the baseline

TABLE 1
Demographic Details of Participants in the 1 Month Exercise plus Deep Breathing (EDB) Group and the 1 Month Control Groupa,b

	EDB	CONTROL
Number	24	28
Age (yrs)	60.1 ± 1.6 (42-76)	65 ± 2.0 (42-87)
Type of Surgery (%)		
Partial mastectomy + axillary clearance	58.3	42.9
Total mastectomy + axillary clearance	41.7	57.1
Received Radiotherapy (%)	79.2	92.9
Received Chemotherapy (%)	33.3	46.4
Time since onset of LO (yrs)	5.5 ± 0.9 (1-15)	3.5 ± 0.7 (0.5-15)
Baseline limb volume (mls)	2873 (2118-3672)	3278 (2848-3916)

[a] means plus standard errors, arm volume presented as medians plus 25th & 75th percentiles. [b] there were no statistically significant differences between the exercise and control groups.

measurement. Interestingly, although participants were instructed not to perform the exercise during the 24 hour and 1 week follow up period, there were reductions at these follow up measurements of 46mls (p = 0.04, 4.3%) and 33mls (p = 0.03, 3.5%) respectively.

Truncal Fluid

Directly after performing the exercise, there was a median reduction in truncal fluid of 31.6 mls from a median truncal volume of 15,466 mls (p = 0.148 n.s.). The reduction in truncal fluid was insignificant at the 30 minute point (21.1 mls; p = 0.417 n.s.), and after this time there was little to no fluid change up to and including the 60 minute point. There was negligible change in truncal fluid at 24 hours and 1 week follow up.

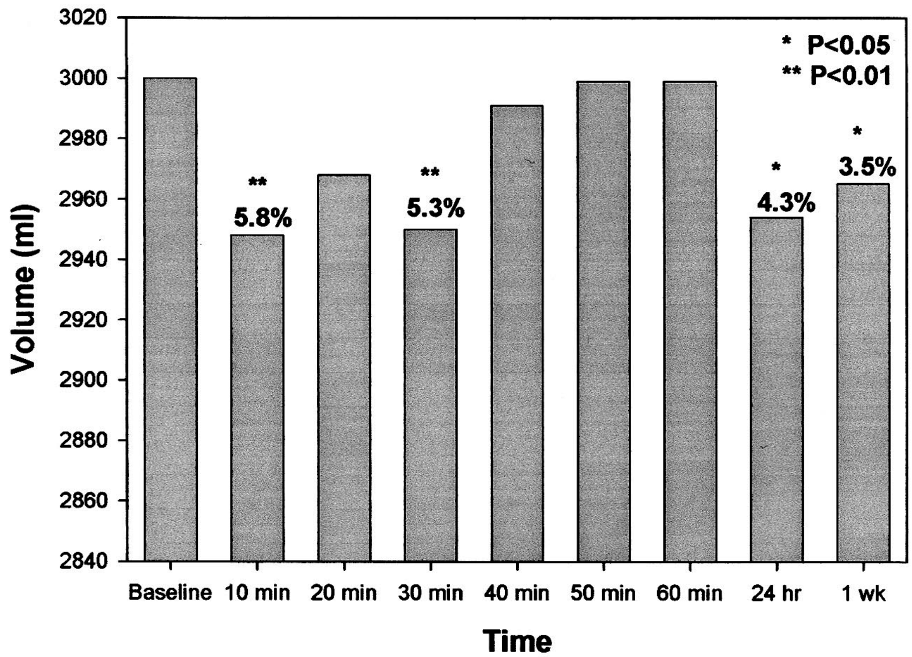
Tonometry

Tonometry readings taken at the forearm, upper arm and anterior thorax did not change significantly at the 60 minute point, 24 hour or 1 week followup in the exercise group.

Reported Subjective Arm Symptoms

Symptoms such as pain, burning feeling and limb temperature were only rated as being slightly problematic and changed little throughout the trial period (*Table 2*). Reported arm heaviness and tightness decreased directly after the exercise regime (p = 0.05, 0.02, respectively) with the reduction in tightness being sustained at 24 hours (p = 0.00). The reduction in heaviness was sustained at 24 hours (p = 0.01), and 1 week (p = 0.01). Reported sensations of pins and needles were significantly reduced at 24 hours (p = 0.03) and 1 week (p = 0.03), while perceived limb size was significantly reduced at 1 week (p = 0.04).

One Month Follow up



	Baseline	10 min	30 min	24 hr	1 wk
25th Percentile	2216	2168	2203	2180	2215
75th Percentile	3656	3705	3624	3669	3655

Fig. 2. Median arm volume and percentage lymphedema reduction at various periods after exercise in women suffering post-mastectomy lymphedema.

In the continuing smaller cohort of 24, after one month of exercise, the median volume reduction was 101mls ($p = 0.07$; *Table 3*), which represents a percentage reduction of 9%. This is in comparison with the control group which remained relatively unchanged having only had a reduction of 7 mls ($p = 0.975$; *Table 3*). The correlation between the response directly after exercise (in terms of arm volume reduction) and those who responded after 1 month of exercise was strong and statistically significant ($r = 0.551$; $p = 0.005$; *Fig. 3*).

At the end of the one month program there was an improvement in the anterior thorax measurement ($p = 0.018$; *Table 3*). This improvement was also statistically significant in comparison to the control group ($p = 0.005$; *Table 3*), with the measurements actually getting worse in this area in this group. In particular, the exercise group of 12 participants had considerable fibrotic induration in the anterior thorax (measurement < 7 units) which significantly improved at the 1 month measurement (improvement of 2.6 units, $p = 0.00$). In these participants 11 had undergone previous radiotherapy and the other had long standing (> 30years) lymphedema.

The exercise group also experienced statistically significant reductions in reported arm heaviness and perceived limb size after 1 month ($p = 0.00$ and 0.02 respectively; *Table 2*). These reductions were also statistically significant in comparison to the control group ($p = 0.044$ and 0.016

TABLE 2
Change in Subjective Symptoms at Various Periods after Exercise in Women Suffering Post-mastectomy Lymphedema

Symptom	B ± S.E.	Tx ± S.E.	p =	24 hrs ± S.E.	p =	1 wk± S.E.	p =
Pain	0.9 ± 0.29	0.8 ± 0.04	0.32	1.03 ± 0.28	0.52	0.71 ± 0.21	0.49
Tightness	1.9 ± 0.39	1.7 ± 0.06	0.02*	1.23 ± 0.19	0.00*	1.73 ± 0.37	0.67
Heaviness	4.0 ± 0.43	3.8 ± 0.09	0.05*	3.00 ± 0.17	0.01*	3.03 ± 0.37	0.01*
Pins & Needles	1.3 ± 0.34	1.3 ± 0.34	1.00	0.56 ± 0.34	0.03*	0.68 ± 0.32	0.03*
Burning Feelings	0.6 ± 0.31	0.4 ± 0.14	0.19	0.53 ± 0.22	0.68	0.16± 0.33	0.18
Limb Temperature	1.5 ± 0.33	1.5 ± 0.03	0.32	1.58 ± 0.33	0.94	1.20 ± 0.30	0.25
Perceived Size	5.5 ± 0.45	5.4 ± 0.79	0.32	4.99 ± 0.29	0.08	4.99 ± 0.25	0.04*

B = Baseline; Tx = after exercise regime; 24 hrs = 24 hour follow up; 1 wk = 1 week follow up

TABLE 3
Change in Parameters in the Deep Breathing plus Exercise (EDB) Group and the Control (CO) Group at the End of 1 Montha

	EDB			CO		EDB	vs CO
Parameter	Baseline	1 month	p	Baseline	1 month	p	p
Arm Volume	2873	2772	0.070	3278	3271	0.975	0.211
	(2118 – 3612)	(2062 – 3610)		(2848 – 3916)	(2829 – 3959)		
Ton Forearm	4.8 ± 0.2	5.1 ± 0.2	0.163	4.7 ± 0.2	5.1 ± 0.2	0.141	0.392
Ton Upper Arm	6.0 ± 0.3	6.0 ± 0.2	0.778	6.6 ± 0.3	6.7 ± 0.3	0.565	0.120
Ton Anterior Thorax	7.3 ± 0.2	8.3 ± 0.4	0.018*	6.9 ± 0.4	6.5 ± 0.4	0.102	0.005*
Pain	0.9 ± 0.1	0.5 ± 0.3	0.870	2.6 ± 0.3	2.9 ± 0.4	0.204	0.309
Heaviness	4.0 ± 0.1	2.6 ± 0.4	0.020*	4.6 ± 0.5	4.5 ± 0.6	0.803	0.044*
Tightness	1.9 ± 0.1	1.6 ± 0.5	0.970	3.3 ± 0.5	3.1 ± 0.5	0.624	0.789
Pins & Needles	1.3 ± 0.3	0.5 ± 0.3	0.120	2.4 ± 0.5	2.5 ± 0.5	0.720	0.194
Burning Feelings	0.6 ± 0.1	0.6 ± 0.3	0.750	1.4 ± 0.3	1.4 ± 0.3	1.000	0.861
Limb Temperature	1.5 ± 0.1	1.4 ± 0.5	0.480	2.1 ± 0.3	2.4 ± 0.4	0.348	0.235
Perceived Size	5.5 ± 0.8	4.8 ± 0.2	0.000*	5.5 ± 0.4	5.1 ± 0.4	0.210	0.016*

[a] means plus standard errors, arm volume presented as medians plus 25th & 75th percentiles.

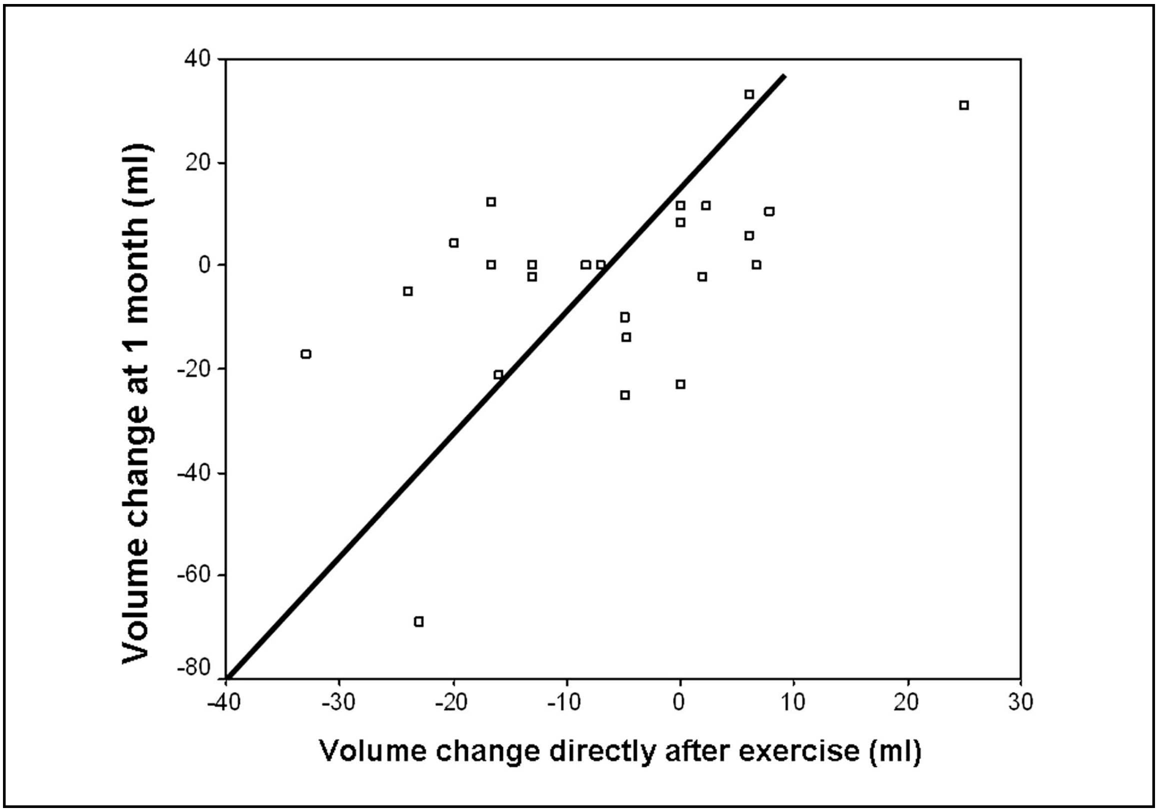


Fig. 3. Correlation of volume reduction directly after exercise with volume reduction after 1 month of exercise (n=24).

respectively; *Table 3*) with these symptoms remaining relatively unchanged in the control group. The exercise group experienced a median reduction of 41.7 mls in truncal fluid as measured by bioimpedance, but this was not statistically significant (p = 0.542).

Adverse Effects & Compliance

The standardized arm exercise plus deep breathing was well tolerated with no reported adverse effects. The smaller sample size in the group who undertook the exercise regime for one month was due to participants unable to complete the time period because of sickness or personal reasons. There was a 90% compliance rate in the group (n = 24) who performed the regime over the 1 month period.

DISCUSSION

This trial has demonstrated that arm volume and percentage edema is significantly reduced immediately after performing 10 minutes of standardized deep breathing and arm exercise and that this reduction is sustained for at least 30 minutes. Although these reductions are small compared to what has been reported by conventional treatment (i.e., CDT), the time invested in this self-administered treatment is minimal. The reductions observed at the 24 hour and 1 week follow up may be related to participants continuing the exercise at home (even though they were instructed not to). It also shows that this form of exercise does not increase fluids in the interstitium, or exacerbate the edema. This supports evidence that women with post mastectomy lymphedema can undertake some forms of exercise without exacerbating their condition. A pilot study by McKenzie & Kalda (2003) that involved 7 women who undertook 2 months of aerobic and resistance training found that there was no statistical increase in arm volume or circumference (20). However, unlike this trial, there was no statistical reduction in these parameters either.

Truncal fluid reduction by exercise was not statistically significant, perhaps because the truncal volume is large compared to any fluid shifts caused by the exercise and deep breathing. There was also a reduction in reported arm heaviness and tightness directly after performing the regime and at 24 hours. At the 1 week follow up, heaviness, pins and needles, and perceived limb size were significantly reduced. These reductions were important as sensations of heaviness and tightness were reported to be particularly problematic for these women.

The group (n = 24) who performed the exercise and deep breathing regime over one month showed a median reduction in arm volume of 101mls and in percentage edema of 9%, but this reduction did not reach statistical significance ($p = 0.07$). Interestingly, other studies have shown that maintenance regimes, such as compression, worn over a 2-4 week period generally resulted in a reduction in the range of 4-7% (19,21-23).

The fact that there was a significant correlation between those who experienced a good volume reduction directly after performing the exercise and deep breathing and those who experienced a reduction after 1 month also gives clinicians a way of determining who will most benefit from this type of regime, with those who experience an arm volume reduction after 10 minutes of performing the regime being more likely to continue to respond over a longer time period.

The 1 month group also experienced a reduction in truncal fluid, and statistically significant improvements in arm heaviness and perceived limb size. Also of importance was the statistically significant improvement in tissue hardness in the anterior thorax area. The action of the exercise, which moves the pectoralis major muscle over the underlying structures may have helped to loosen underlying adhesions and/or fibrosis, improving the general condition of the tissues. This is certainly a point worth pursuing.

The improvements in the group who performed the exercise and deep breathing program over one month were in stark contrast to the comparison control group. In the control group, the arm volume, subjective symptoms and tonometry readings remained relatively unchanged or in some cases even got worse. The worsening of limb volume in this control group is consistent with a study by Szuba et al (2003) which described the progression of a group of patients who received decongestive lymphatic therapy (DLT) followed by maintenance treatment (daily self-massage and compression garments). These patients had a mean increase in limb volume of 32.7 mls one month after DLT, and a further increase of 35 mls after six months (24). Therefore the longer term reductions over 1 month of exercise, in comparison with the control group, demonstrate that this regime can play a positive role in the maintenance of post-mastectomy arm edema.

Combined deep breathing and gentle arm exercise represents an easy to implement and cost effective regime that can be utilized by women with secondary edema in the home environment. These results also suggest that other forms of exercise that incorporate deep breathing and arm exercise, such as Tai Chi, Qi Gong and Yoga may also be beneficial for post-mastectomy lymphedema sufferers. The use of such exercises should, however, be carefully monitored. Further, these exercises may be useful as adjunct treatment along with CDT.

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