

## LOW INTENSITY RESISTANCE EXERCISE FOR BREAST CANCER PATIENTS WITH ARM LYMPHEDEMA WITH OR WITHOUT COMPRESSION SLEEVE

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### ABSTRACT

*Clinical trials of the effect of physical exercise on breast cancer related arm lymphedema (ALE) are very rare. The aim of this study was to examine if controlled low intensity arm exercises with weights, with or without a compression sleeve, influence breast cancer related ALE. Thirty-one breast cancer treated patients with small or moderate ALE were included in the study. A specifically designed arm exercise program was performed with or without compression sleeve on different days and in a randomized order. Measurements were performed before, directly after and 24 hours after the exercise intervention, with water displacement method and multiple frequency bioelectrical impedance analysis (n=10) for volume of the arms and Borg's scale for perceived exertion during training. There was an increase of total arm volume of the lymphedema arm immediately after the exercise intervention for both with and without sleeve conditions ( $p \leq 0.01$ ). At 24 hours, no volume increase was found compared to pre-exercise and both groups showed tendency towards reduced lymphedema relative volume ( $p \leq 0.05$ ). The patient's rating of perceived exertion was low regardless of whether a sleeve was worn, but*

*was significantly higher when exercising with the sleeve. We conclude that low intensity exercises can be performed by patients with arm lymphedema without risk of worsening the edema. Exercises without the sleeve may be of benefit provided compression sleeve is worn regularly.*

**Keywords:** breast cancer, arm lymphedema, exercise, treatment

In Sweden, 27% of all cancer diagnoses in women are breast cancer and 10% of the female population will be diagnosed with breast cancer during their lifetime. The incidence in Sweden has slowly increased since the 1960s along with the 5-year survival rate, which now is about 85% (1). Most patients will have a combination of surgery and radiotherapy for control of the disease locally. From a physiotherapeutic perspective, interest is focused on morbidity related to these two treatments.

### *Breast Cancer Treatment*

The most common treatment for breast cancer in Sweden currently is breast conservation surgery, followed by radiotherapy to the residual breast tissue (2). Breast cancer

unsuitable for treatment with breast conservation can be treated by mastectomy with removal of the breast tissue from the chest wall muscles (pectoralis major, rectus abdominis and serratus anterior), which are left intact (3). In the axilla, 8-10 nodes are removed for staging of the breast cancer disease. The operation involves the nodes below and medial to the axillary vein (level I and II) (4) sparing the long thoracic and the thoracodorsal nerves but often dividing nervus intercostobrachialis. The wound surface is relatively large and fibrotic tissue developing during wound healing following axillary surgery has been related to occlusion of the remaining lymphatic channels (5).

Following breast conservation surgery, radiotherapy is given tangentially to the remaining breast tissue and with axillary metastases, radiotherapy is given to the thoracic wall and to lymph nodes in the axilla, fossae supra- and infraclavicularis, and sometimes to the sternal nodes. The upper limit is the acromioclavicular joint and 2/3 of the caput humeri (6). We have reported that post-operative radiotherapy to the axilla contributes to lymphedema as well as progressive muscle damage, probably due to vascular alterations (7). The increasing fibrotic tissue might be mediated additionally by inflammation accompanying vessel damage (8), and such accumulation of fibrotic tissue in the shoulder area may also cause nerve entrapment (9) associated with pain and further reduction of muscle function.

### *Lymphedema*

The lymphatic system moves fluid, macromolecules and formed elements from within the interstitial spaces into initial lymphatics and to pre-collectors and collectors. Lymph is also propelled through numerous lymph nodes and finally returned to the blood system and into the subclavian veins (10). Lymph vessels possess valves, and each segment between two valves represents a unit called the lymphangion (11). The

lymphangions are richly provided with nerve structures belonging to the autonomic nervous system. This system and the muscular elements in the walls of the angions generate contractions, and this "pumping" activity is one of the most important mechanisms for generating lymph flow. Lymphatic drainage of the arm is primarily accomplished through lymph vessels that pass through the axilla.

In breast cancer related arm lymphedema, drainage is damaged by axillary surgery and radiotherapy. However, increased arterial flow can also be demonstrated (12) as well as abnormal venous outflow (13), and higher venous pressure (14) suggesting a more pervasive influence on the circulatory system.

A review of articles defining breast cancer-related lymphedema as a volume at least 10% larger than the contralateral arm report an incidence of about 10% when axillary node dissection is performed and about 40% when axillary radiotherapy is added (7,15,16). The prevalence of arm lymphedema increases with time and 70-80% develop within 3 years after cancer treatment (15). Psychosocial aspects have also been examined revealing depression, anxiety and impairments related to work, social and intimate relationships (17) as well as problems with understanding of the chronic disease, including coping strategies (18). Tobin et al (19) found that breast cancer patients with arm lymphedema showed greater psychological morbidity and impaired adjustment to illness than those without lymphedema. A recent study also shows that even if the lymphedema has been treated, breast cancer patients with lymphedema reported poorer quality of life than patients without lymphedema (20).

Compression therapy, manual lymph drainage and intermittent pneumatic compression are the most commonly used conservative treatments for arm lymphedema. All treatments, on their own as well as in combinations, have been demonstrated effective by Johansson et al (21,22).

### *Muscle Strength*

Several studies report reduced arm and shoulder muscle strength following breast cancer treatment with an incidence of about 20% (23-26). Aitken et al (27) found the power of the pectoralis major to be significantly reduced for breast cancer patients who received radiotherapy. The connection to the pectoralis major has been confirmed by other studies revealing strength reduction for shoulder adduction, flexion, and inward rotation (7,28).

### *Physical Activity*

A review of 26 exercise intervention studies involving various cancer patient populations has reported consistent and positive outcomes (29). Benefits have included reduced fatigue, nausea, body fat, anxiety and depression and increased muscle strength, lean body mass, and aerobic capacity, enhanced immune function, and improved quality of life ratings. Breast cancer has been the most extensively studied in terms of exercise intervention, however, research specifically addressing lymphedema is scarce. This is somewhat surprising given the overwhelming body of literature demonstrating physical activity to be the most effective intervention for maintaining strength and muscle mass, reducing body fat, improving functional capacity and increasing flexibility, the reverse of which are the primary difficulties reported for lymphedema patients.

Breast cancer patients treated with axillary dissection, are often advised to avoid heavy work with the arm and not to overload the lymphatic system and to be careful (30). Such advice promotes the idea that inactivity is beneficial. On the other hand, they are advised to be active with the arm to stimulate the same system and to prevent strength reduction. This seemingly contradictory advice obviously is confusing for the patient and needs clarification.

Information about the risk of developing or worsening arm lymphedema by physical exercise is very sparse. A few pilot studies have maintained that controlled physical activity, moderate as well as heavy, does not pose a risk for lymphedema (31,32). However, the influence on arm lymphedema of more specific exercises aimed at increasing muscle strength has not been examined previously.

The aim of this study was to examine the influence of a program of physical exercises on the degree of arm lymphedema following breast cancer treatment. Further, the influence of wearing a compression garment during the exercise was also investigated.

## *MATERIAL AND METHODS*

### *Patients*

Patients were identified through the physiotherapists' registry of lymphedema patients at the Physiotherapy Department, Växjö Central Hospital and the Lymphedema Unit, Lund University Hospital, Lund, Sweden in September 2002.

The inclusion criteria were unilateral arm lymphedema following breast cancer treatment, not older than 70 years, lymphedema arm volume 10-40% greater than the contralateral arm [slight or moderate lymphedema according to Stillwell (33)], the onset of the edema had to be 3 months or more after surgery and persistent for at least 6 months. Excluded from the study were women with recurrence of cancer, intercurrent diseases affecting the swollen limb, or difficulties in participating in the study such as dementia or language limits.

The radiotherapy dose given was 50 Gy in fractions of 2 Gy/day, 5 days per week over 5 weeks.

Forty-two patients were identified and included in the study. They were randomly asked to take part in the study, and 4 declined due to lack of time or long travel distance. At the start of the trial, 7 patients did not reach the 10% level and were not

**TABLE 1**  
**Characteristics of the Study Group of Women with Arm Lymphedema**  
**Following Breast Cancer Treatment (n=31)**

	m (SD)	md (range)	number
Age, years,	55.3±7.3	54(40-68)	
Surgery			
Type, partial/mastectomy			13/18
Axillary nodes, number dissected	13.3±5.2	13(5-27)	
Edema			
Duration, months	66.7±51.7	54(6-212)	
Site, right/left			21/10
In dominant arm			23
Absolute volume, ml	396±163	351(140-824)	
Relative volume (%)	17.2±7.0	17.6(10.5-32.4)	
Lifestyle-related factors			
Body Mass Index	25.9±3.2	26.3(20.8-33.4)	
Weekly regular physical activity	4.6±3.6	4.3(0-14)	

included. Demographic data for the remaining patients (n=31) are presented in *Table 1*.

The study was approved by the Research Ethics Committee, Lund University, 2002, LU 301-02.

### *Measurements*

#### *Arm volume*

Arm volume was measured with the water displacement method (Archimedes principle), which has been used as the gold standard of limb volume measurements (34). The method has been described by Kettle (35) who found a standard deviation of 1.5% from the mean volume of repeated measurements. Bednarczyk et al (36) carried out a validity test for the water displacement method with a computerized limb volume measurement

system (CLEMS) and found a high correlation coefficient ( $r=0.992$ ). They also showed that measuring plaster figures, CLEMS had a high test-retest correlation ( $r=0.999$ ).

Before this study was started the measurement reliability between the two study centers was tested. The standard coefficient of variation was 0.12% for Lund and 0.24% for Växjö which is considered very good.

A cylindrical container with a soft drain pipe 50 cm above bottom was filled with water. Each arm was submerged in a straight position with the fist resting with the proximal phalanges at the bottom. The water displacement was collected in a tank and weighed in grams and translated into milliliters assuming 1 gm/ml (*Fig. 1*) The contralateral arm was used as a control on each occasion.



Fig. 1. Arm volume measurement with water displacement method.

The lymphedema absolute volume (LAV) was obtained by calculating the difference in volume between the lymphedema arm and the contralateral arm (37,38). The lymphedema relative volume (LRV), taking build into account, was defined as an increase in volume of at least 10% compared to the non-operated arm (33) using the following formula:

$$\frac{\text{Vol. lymphedema arm} - \text{vol. contralateral arm}}{\text{vol. contralateral arm}} \times 100$$

A correction for the natural asymmetry of the arms was performed with 1.6% for right-handed and 1.4% for left-handed participants (39).

#### *Multiple frequency bioelectrical impedance analysis (MFBIA)*

Impedance measurements of the arms were recorded using a swept frequency bioimpedance meter (model SFB3, SEAC Brisbane, Australia) in a tetra-polar electrode setting. The impedance at zero frequency ( $R_0$ ) and the impedance at the characteristic frequency ( $Z_C$ ) were determined. These parameters have been shown to be reliable predictors of extracellular water (ECW) and total body water (TBW), respectively (40). Since lymphedema is suggested to mainly affect fluid volume in the extracellular compartment, changes in  $R_0$  can be used to

monitor these types of changes (41). To minimize global effects due to various possible reasons, including patient stress, hormone cycles and food/beverage intake, ratio measurements were used: ECW affected limb / ECW unaffected limb =  $R_0 / R_0^*$  ( $R_0^*$  is the resistance at zero frequency in the affected limb).

During the measurement the patient was resting in a supine position with the arms resting horizontal with palms down and the electrodes positioned at wrist and axilla level. The measurements were performed on the right hand side, followed by the left hand side and lastly repeated on the right hand side in order to monitor the specific uncertainties due to electrode displacement and measurement reliability. The basis of the analysis was a significance test of resistance differences between the affected and healthy limb using the additional information of the uncertainty measurement and corrections for estimated differences between dominant and non-dominant side.

For practical reasons, only 10 of the last patients in the study were examined with MFBIA.

#### *Subjective sensations*

The experiences of heaviness and tightness, which are common sensations in the affected arm (44) were each scored by



*Fig. 2. Exercise program with weights including shoulder flexion, abduction and horizontal adduction together with elbow extension and flexion.*

the patient standing, with arms hanging, on a 100 mm horizontal visual analogue scale (VAS). The endpoints were “no discomfort” (0 mm) and “worst imaginable” (100 mm) (45). The initial scores before exercise sessions were made available to the patient for scoring after the sessions (46).

#### *Perceived exertion*

The patients perceived exertion after physical exercise were rated on a Borg scale ranging from 6 (minimum) to 20 (maximum) where every other step was provided with a verbal statement from “very, very light” to “very, very hard” (47).

#### *Physical activity*

A questionnaire was used to determine the weekly level of regular physical activity over the previous year, lasting more than 30 minutes each time (48).

#### *Standardized Exercise Program*

The patients performed the exercises individually according to a standardized program using dumbbells described and clinically evaluated at the Breast Cancer Physical Therapy Center, Philadelphia, USA (49). Adduction in the supine position was added to the program because strength in this movement was, in a prior study, recognized

as being reduced after breast cancer treatment (7). The exercises (*Fig. 2*) were performed equally with both arms 10 times in the following order:

#### *Standing position*

1. *Shoulder flexion* with straight arms, hands in a neutral position
2. *Shoulder abduction* with straight arms in a motion line as close to the frontal plane as possible. When the motion starts, arms are in a neutral position and then, while moving, turns into outward rotation.

#### *Supine position*

3. *Shoulder horizontal adduction* with straight arms, palms towards the ceiling and hands meeting in front of the body with arms perpendicular to the body.
4. *Elbow extension*, starting with the arm perpendicular to the body and elbow in flexion with elbow tip towards the ceiling, then straightening the arm in elbow extension with hand towards the ceiling

#### *Standing position*

5. *Elbow flexion*, starting with elbows extended, forearms supinated and upper arm close to the body. The flexion ends with hands as close to shoulders as possible.

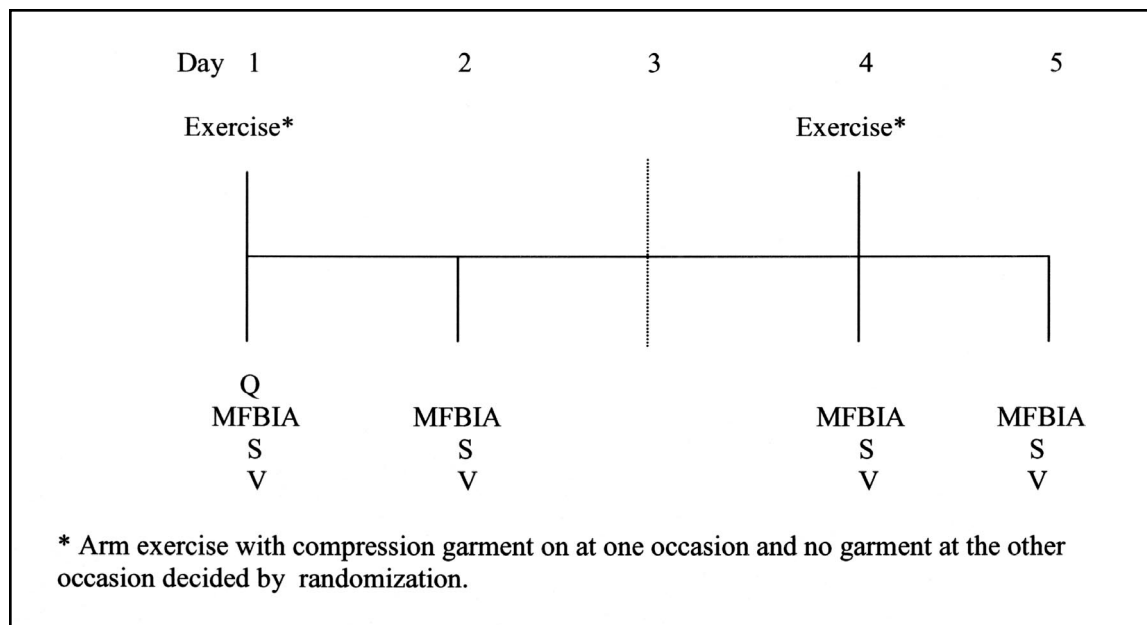


Fig. 3. The questionnaire (Q) was applied once and multiple frequency bioelectrical impedance analysis (MFBIA), subjective sensations (S) and arm volume (V) were measured pre-, immediately post- and 24 hours post-exercise.

Exercises 1-3 (long lever-arm) were performed with 0.5 kg weights and exercises 4-5 (short lever-arm) with 1.0 kg weights according to the Philadelphia program.

### Design

At least 2 weeks before the start of the study the women had to wear a compression sleeve, of standard type or custom-made, during the day and night or daytime only according to their usual procedures during the prior 3 months, to maintain a steady volume level before the study. The compression grade was at least class II (23-32 mmHg according to the European Committee for Standardization (50), and most of them had a silicon top band. The sleeve was no older than 3 months.

The study design (Fig. 3) included 5 days with two training sessions with measurement the day after. One day of rest was held between the two sessions. The patients wore the compression garment during one session

and not at the other occasion and a randomization was carried out to determine which condition was initiated first.

Measurements were performed in the following order: questionnaire, MFBI, subjective assessments and volume. After the measurements had been performed, a session of exercises 1-5 was completed directly followed by assessment of perceived exertion on Borg scale. This session was repeated twice, in all 3 sessions, with 2 minutes pause between each session. Directly after the third session the measurements, except for the questionnaire, were performed and then again after 24 hours. The measurements and training were performed at the same time of day, and the garment was worn in between according to the customary procedure for each patient.

### Statistics

Comparisons of repeated measures within the subjects were performed using

**TABLE 2**  
**Total Arm Volume (TAV), Lymphedema Absolute Volume (LAV), Lymphedema Relative Volume (LRV), Multiple Frequency Bioelectrical Impedance Analysis (MFBIA) And Subjective Assessment On Visual Analogue Scale (VAS) Of Experienced Heaviness And Tightness in Mean±SD in the Lymphedema Arm in Breast Cancer Patients (n=31), Pre-, Immediately Post-and 24 Hours Post-Exercise**

		pre-exercise	immediately post-	24 hours post-
<u>Without compression sleeve</u>				
TAV (ml)	edema	2728±409	2737±411**	2726±401
	healthy	2331±355	2336±352	2338±351
LAV (ml)		397±159	401±170	387±160
LRV (%)		17.3±6.7	17.4±7.1	16.8±6.8*
MFBIA		1.186±0.175	1.208±0.199	1.179±0.156
VAS (mm)	heaviness	9.9±14.6	10.1±16,2	8.8±15.9
	tightness	7.0±12.7	8.2±12.0	7.0±13.1
<u>With compression sleeve</u>				
TAV (ml)	edema	2719±403	2731±407**	2717±408
	healthy	2333±347	2334±344	2340±356
LAV (ml)		386±164	397±169 *	377±162
LRV (%)		16.8±7.0	17.2±6.9††	16.3±6.7†
MFBIA		1.160±0.162	1.189±0.176†	1.168±0.151
VAS (mm)	heaviness	9.5±13.4	10.1±14.9	9.7±14.1
	tightness	7.0±13.4	7.9±11.7	6.4±12.4
† p=0.07; †† p=0.06; * p ≤ 0.05; ** p ≤ 0.01; p-values related to comparison with pre-exercise data.				

paired t-test for continuous data and Wilcoxon ranks test for ordinal data (Borg scale). A level of  $p \leq 0.05$  was adopted as the criterion for statistical significance.

## RESULTS

Fifteen patients were randomized to start without compression sleeve and 16 started with. However, the analysis of randomized start with or without sleeve showed no difference in arm volume between the two training occasions. Thus, the following results are presented only as differences between

exercises with or without sleeve not taking into account which condition was utilized first.

### Arm Volume

Volume measurements before the start of exercise on day 1 revealed a significant volume difference ( $p > 0.001$ ) between the affected ( $2726 \pm 404$  ml) and non-affected arm ( $2331 \pm 352$  ml). Directly after the exercise sessions, a significant increase in *total arm volume* in the affected arm was found, both for exercises with and without sleeve and at



**TABLE 3**  
**Patients Rating of Perceived Exertion on Borg Scale after Each Exercise Session**

	After session 1	After session 2	After session 3
Without compression sleeve	8.8±2.1 (6-13)	9.5±2.2 (6-14)**	9.9±2.4 (6-15)***
With compression sleeve	9.6±2.2 (7-13)	9.7±2.2 (7-13)	9.9±2.3 (7-15) †

n=31; data expressed as Mean±SD (range); † p=0.06; \*\* p ≤ 0.01; \*\*\* p ≤ 0.001, p-values related to comparison with session 1.

24 hours, no significant difference was found compared to the volume before exercise (Table 2). The *lymphedema absolute volume* (LAV) also increased immediately after the exercise sessions but only in the sleeve group, similarly to the *lymphedema relative volume* (LRV) borderline significance of p=0.06. At 24 hours, LRV was significantly reduced in the without sleeve group compared to before exercise (Table 2).

#### *Multiple frequency bioelectrical impedance analysis (MFBI)*

No difference between the groups with or without compression sleeves was found prior to the exercise intervention. Immediately after the exercise, a tendency towards significant (p=0.07) increase was found in the group wearing a compression sleeve. The following day, no difference was found compared to before exercises (Table 2).

#### *Subjective sensations*

Thirteen patients (42%) experienced heaviness and 16 (52%) experienced tightness in the arm pre-exercise. There were no changes in mean rating of heaviness or tightness experienced on the VAS immediately after the exercise or the following day in either of the groups.

#### *Perceived exertion*

The patients' ratings of exertion on the Borg scale were in general expressed as "very light" (rating 9). The rating was higher with sleeve than without (p=0.007) after the first session. When exercising without sleeve, the rating level increased both after session 2 and 3 compared to session 1. When exercising with sleeve on, only a tendency (p=0.06) toward increased exertion was found after session 3 (Table 3).

#### *DISCUSSION*

The results in the present study indicate that a controlled arm exercise program of low intensity does not increase volume in the affected arm in breast cancer related arm lymphedema. However, a significant increase of total arm volume was found immediately after exercise performance, whether the exercises were performed with or without compression sleeves; this increase was lost by 24 hours.

Dynamic muscle contractions through isotonic resistance exercises more than double the contraction frequency and lymph flow in healthy subjects (51). The combination with compression garments is considered to add an effect on lymph flow from the affected limb, acting as a counterforce to the muscle

contractions, which are the most important stimulus to lymph flow. The compression sleeve may also limit capillary filtration by opposing capillary pressure (49,52,53). However, in the present study, we found arm volume increase in the group wearing compression sleeves, not only shown in total arm volume but also in LAV as well as in LRV and by the MFBIA measurements. This effect was not seen in the group not wearing compression sleeves during exercises, indicating that the sleeve did not impede the volume increase as one would expect, but did on the contrary contribute to its worsening. One possible explanation could be that the compression sleeves were inferior but this is not likely as the sleeves applied were individually fit by experienced physiotherapists and not older than three months, which is half the time for effective compression recommended by the providers. Another possibility could be a rebound effect where the limb slightly expands after being released from compression as sometimes is seen post-compression bandaging.

Alternatively, excessive loading of the affected arm could be a reason for lymphedema increase with possible muscle damage and associated inflammatory response. This explanation is highly unlikely because the intensity and volume of exercise were quite low and not expected to cause such damage. The Borg scale ratings of perceived exertion support this view. The scale is more commonly used for rating of exertion experienced by aerobic training but can also be used for strength effort. In the present study, the rating was in general low (9-10, very easy) and, although increasing in both groups after the last session (third), the rating was still low. However, after the first session, the patients reported that exercising with the sleeve was harder than without. This finding may be explained by the compression sleeve working counter to increased blood circulation and, therefore, to some extent, impeding oxygen supply to the muscles at the start of exercise. Also, the sleeve may impede

movement making the overall effort more difficult. At the end of session 3, both groups rated effort at the same level implying that blood circulation was now sufficient, or some warmup effect had decreased perception of effort, or that perhaps stretching and recoil of the garment had warmed the material and increased its compliance. Considering the negative influence of the compression sleeve at the start of exercises, the recommendation to the patient must be to perform exercises without the sleeve. On the other hand, the patients spontaneously expressed an experience of compression as a support.

The type of sleeve commonly used had a silicon top-band. Although the top-band is not supposed to influence lymph circulation in a negative way, this may still be the case. When blood flow is increased during exercise, lymph may not flow as freely with the top-band as it does with no sleeve or a sleeve without top-band. If measurements had been performed 30-60 minutes after the exercise intervention, an equalizing value might have been found. The tendency toward reduced LRV the following day in the sleeve group as well as reduction in the group without sleeve (only during exercises) support the theory of delayed reaction. The fact that the arm volumes the day after exercises were equivalent to the values before the exercises in both groups, indicates no negative influence on the arm lymphedema and might lead to the conclusion that, concerning arm volume, it does not matter whether the sleeve is worn during exercises or not, as long as it is worn the rest of the time as prescribed. Therefore, the decision on wearing or not wearing sleeve during exercises can be left to each patient depending on whether the patient experiences increased effort or support from the sleeve.

The fact that the arm volume, although increased after exercise, returned to pre-exercise volume the following day supports prior investigations that compression sleeves are effective in arm lymphedema treatment (22). Although the compression sleeve failed

to keep the arm volume steady during exercise it may still be important to wear the sleeve on a long-term basis to prevent the ongoing deterioration of the edema that otherwise will take place (54). Further research is required to examine the role of compression and other interventions post-exercise.

The rating level of perceived exertion on a Borg scale after each exercise session turned out to be low with a mean of 9, which corresponds to “very light” in verbal expression. However, the present group had a higher sport activity level (median 4 occasions/week) compared to a previously examined group of similar breast cancer treated women with arm lymphedema (median 2 occasions/week) (7) implying that the patients in this study, although randomly selected, were more interested in physical activity and therefore better trained and perhaps stronger than a general population of breast cancer treated women. In order to get a sufficient training effect, with increased muscle strength and/or endurance, the intensity, that is weight lifted, probably needs to be raised. As very little is known about the influence of heavy weights in lymphedema patients, we preferred, in the present study, to keep the weights light in agreement with the clinical experience (49). Also, in a randomized study by McKenzie and Kalda (32), the resistance level was adjusted to what was tolerated by each patient but as the level was not reported numerically, the results cannot fully be compared to those in the present study. However, the McKenzie and Kalda study also supports our results showing no increase of volume after an 8-week progressive upper-body exercise program in 14 patients (7 cases/7 controls) with breast cancer related arm lymphedema.

In terms of increases in muscle size and strength as well as maintenance of functional ability, much higher levels of resistance or weight lifted have been recommended (55). Sets of 10 to 12 repetition maximum (RM) is maximum number of repetitions that can be

completed at a given load before fatigue prevents any further repetitions in that set) is considered at the lower end of intensity with much higher intensities often prescribed in young and old people, both healthy and patient populations. There are also several other programming variables, such as rest period between sets, which have an influence on the adaptations that occur. Thus, future studies need to focus on increased intensity levels as well as manipulation of rest intervals and other variables to optimize the benefits of resistance exercise for the lymphedema population.

Many parameters seem to affect the MFBI including patient stress, coffee, and hormone cycles, making it difficult to isolate changes due to exercise and other interventions. An assumption is made that many of these parameters affect both arms similarly. Therefore, ratio measurements are used to negate these parameters. However, some parameters cannot be negated in this way because of their single-sided nature. These are tissue characteristics and muscle mass due to dominant side and short-term changes due to tension and posture of the measured arm. Along with these parameters, uncertainties concerning the electrodes and the instrument itself form the core of the uncertainty. However, these uncertainties have been taken into account in the analysis. Despite these limitations, the fact that the result is similar to the result for water displacement measures validates the measurement and demonstrates the ability to monitor small lymphedema differences.

We used the visual analogue scale (VAS) to evaluate changes in experiences of heaviness and tightness in the affected arm. VAS is mostly used to evaluate pain but has also in previous studies shown significant changes after lymphedema treatment (21,22). In the present study, no changes were found before and after exercises. However, only half of the patients experienced any of these two sensations and furthermore at a very low level, implying that these variables were not

very sensitive to changes or that the exercise had very little effect. Perhaps these measures should only be applied when experiences of heaviness and tightness are more widespread in the study group.

### CONCLUSION

This study concludes that a controlled, acute arm exercise program with low intensity in terms of weight, produces a slight increase in arm volume that is transient and disappears by 24 hours in the affected arm in breast cancer related lymphedema. However, it must be emphasized that the patients in this study had slight or low-moderate lymphedema volume, and this conclusion may not be applicable to severe lymphedema. Still, the strategy for all lymphedema treatment must be to keep the edema volume low, and this goal can be reached by early detection and early treatment (56).

### ACKNOWLEDGMENT

This study was supported by research grants from the Swedish Cancer Foundation and the Research and Development Centre, Kronoberg County Council, Sweden.

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