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A HOME-BASED WEIGHT LIFTING PROGRAM FOR PATIENTS WITH ARM LYMPHEDEMA FOLLOWING BREAST CANCER TREATMENT: A PILOT AND FEASIBILITY STUDY

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ABSTRACT

It is well documented that resistance exercise can be performed by patients with breast cancer-related arm lymphedema. The aim of this pilot study was to evaluate the feasibility and safety of a 12-week self-administered weight lifting program for arm and shoulder, and its influence on arm lymphedema status, upper extremity muscle strength, and disability. Twenty-three patients with breast cancer-related arm lymphedema performed the program 3 times/week. The weight resistance levels were individually adjusted for shoulder flexion and adduction, and elbow extension and flexion corresponding to a repetition range of 8-12 repetition maximum. A log book was used to evaluate adherence to the program, wearing of compression sleeve and perceived exertion. Measurements were performed before a 2-week control period without intervention, and before and after intervention, and with arm volume measurements every fortnight to check for adverse events.

Results revealed no significant changes during the control period. Adherence to the intervention program was excellent, and two adverse events were registered during the first weeks. After intervention, an increase of shoulder and arm strength (measured by an isometric muscle strength device) was found in all exercises (p=0.001-0.003). A reduction of excess volume was shown, in ml (p=0.03) and percentage (p=0.005), measured by water displacement method. A tendency towards reduction (p=0.07) of fat tissue in the upper arm (n=10) in both arms was found measured by MRI.

In this pilot study, we concluded that a home-based weight-lifting program performed by patients with breast cancer-related arm lymphedema is feasible and safe providing that the program includes regular follow-up for safety.

Keywords: Arm lymphedema, breast cancer, exercise, weight lifting, MRI

Breast cancer patients have been the most extensively studied among cancer patients in terms of exercise interventions. A systematic review and meta-analysis of 66 high quality studies of exercise interventions for cancer survivors reports positive outcomes during as well as after treatment. Some of the most notable positive outcomes from post-treatment exercise were in physical activity level, upper body strength, body weight, body fat percentage, body mass index and fatigue (1). In addition, a meta-analysis by Ibrahim and Al-Homaidh has shown evidence for an inverse relationship between physical activity and mortality in patients already treated for

breast cancer (2). Both meta-analyses support the observation that appropriate physical activity should be embraced by all breast cancer survivors.

Reduced muscle strength is an impairment following breast cancer treatment, which interferes with physical activity. In a prospective longitudinal study of 61 breast cancer patients with axillary lymph node dissection, Johansson et al (3) found reduced shoulder muscle strength not only after 6 months but also 2 years after surgery compared to preoperative values. This was confirmed in a study by Rietman et al (4) examining a mixed group of patients with axillary lymph node dissection (n=124) or sentinel lymph node biopsy (n=57). Another similar study of 23 breast cancer patients showed a negative influence of the breast cancer treatment on work ability and spare time activities in 60% of the patients (5). The impact on work ability for breast cancer patients, also having arm lymphedema, was found in a qualitative interview study by Fu concluding that women, whose jobs required heavy lifting and constant use of the affected limb, suffered profoundly from the physical and functional impact of having lymphedema (6). It may therefore be of importance for breast cancer patients to retain muscle strength in their arms, and it may be of particular importance for patients with arm lymphedema.

An issue interfering with muscle strength training is that breast cancer patients are often advised, based on empiricism, to avoid heavy work with the arm and not to "overload" the lymphatic system and "to be careful." 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 seeming contradiction obviously is confusing for the patient and requires clarification. However, recently a systematic review of exercise in patients with lymphedema has been performed by Kwan et al, and they state that strong evidence is now available on the safety of resistance exercise without risk of development or exacerbation of breast cancer-related lymphedema (7).

Most studies on exercise for women with arm lymphedema have been based on supervised activities, single or in groups (7). However, many women may not want to or are not able to take part in group activities on a regular basis. Therefore, we wanted to evaluate a home-based exercise program.

The main objective of the present pilot study was to evaluate the feasibility of a 12-week self-administered weight lifting program and its influence on arm lymphedema status, upper extremity muscle strength and disability.

METHODS

Subjects and Recruitment

Patients were eligible if they were less than 70 years old, had a history of unilateral breast cancer, but were disease-free, had current arm lymphedema (arm volume difference of 5%) (8) that was pre-existing for more than 6 months, but had not received active treatment for lymphedema during the last month, except for use of compression garments. Patients with a pre-existing medical condition considered contraindicated to participating in a home-based exercise intervention (e.g. chronic neck pain, skin disorder, dementia) were excluded from participating. Permission to contact each patient by phone was obtained through their physiotherapists.

Forty-two patients with arm lymphedema following breast cancer treatment were identified through physiotherapists' registry of lymphedema patients at the Lymphedema Unit, Skane University Hospital and Red Cross Hospital, Solna and met inclusion criteria. Five patients did not answer phone calls, or mails that were sent out. Eleven patients declined to take part due to lack of time (n=2) or long travel distance from

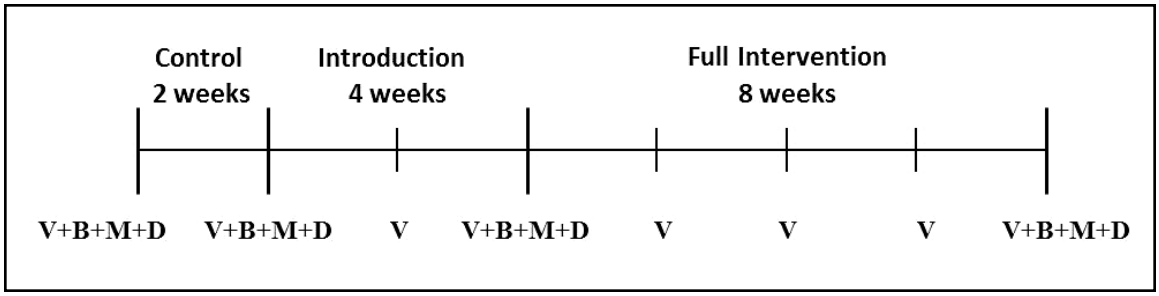

Fig. 1. Study design of the 12-week exercise program; Measurements: V = Volume of the arms, B = Bioimpedance, M = Muscle strength, D = DASH (Disability of arm, hand and shoulder)

hospital to perform measurement procedure (n=9). Twenty-six patients were finally included in the study.

The study was approved by the Regional Ethical Review Board at Lund University (Dnr: 55/2006).

Design

The study design of this pre-post pilot and feasibility study is presented in *Fig. 1.* Before the start of the study the patients had to wear a compression sleeve for at least 2 weeks to maintain a steady arm volume. The compression sleeves were of standard type or custom-made, and were worn during day and night or daytime according to their usual procedures during the last 3 months. The compression grade was at least ccl II (23-32 mmHg) according to the European Committee for Standardisation (9), and most of them had a silicon top band. The sleeve was no older than 1 month.

The study started with a 2-week control period with the intention to determine that the arm volume was steady. The time to ascertain a steady arm volume with at least 2 weeks with a compression sleeve followed by the 2-week control period was chosen according to the results of a study of 4 weeks of treatment including compression garment and isometric exercises (10). The results showed that the largest volume reduction was found during the first week, whereas over the course of the next three weeks the benefit decreased sharply.

After the control period, a 4-week introduction of gradually increasing resistance levels, starting with 50% of 10 repetition maximum (RM) and ending with completed 10RM, was applied for the patients to adjust to the intervention program. If no lymphedema exacerbations were found, the weights were increased by 0.5-1.0 kg every second session until they reached 10RM. After 4 weeks of introduction, the patients performed an 8-week program according to the criteria of intervention.

Intervention

The patients were provided with a box with flexible dumbbells for performance of the weight lifting exercises at home, 3 times per week with at least one day in between. The lowest possible weight was 0.5 kg and the highest 12.0 kg.

Four different exercises were each performed in the following order: (I) shoulder flexion in a standing position, (II) shoulder adduction and (III) elbow extension in a supine position and (IV) elbow flexion in sitting position. These exercises had been tested in a prior study of low resistance training (11).

The weight resistance levels were individually adjusted according to guidelines of the American College of Sports Medicine

(12) for untrained individuals recommending loads corresponding to a repetition range of 8-12 repetition maximum (RM) and training frequency of 2-3 days per week. In the present study the patients were requested to complete at least 8 repetitions for each set and if they could complete more than 12, the resistance was increased with 0.5kg for subsequent sets. Four sets of each exercise were completed at each session with the first set using 50% of the 10RM weight as a warm-up and the subsequent three sets completed with the 8-12 RM weight. A 1-3 minute rest period was taken in between each set.

During the exercise the women were free to choose whether they wanted to use the compression sleeve or not as long as they put it on again immediately following training. This recommendation was based on results from a prior weight-lifting exercise study showing an increase of total arm volume of the lymphedema arm immediately after the exercise intervention for both with and without sleeve conditions. However, after 24 hours of wearing the compression sleeve, no volume increase was found compared to pre-exercise volume (11).

Measurements

Outcomes of interest for this trial were feasibility, lymphedema status, upper extremity muscle strength and disability. Measurements were performed by the same physiotherapists (KJ and PK) who gave instructions to the patients.

Feasibility: Retention and adherence

Retention was assessed by withdrawal rates and adherence was assessed by a log book, including date for session, wearing of compression sleeve, weight resistance and perceived exertion for each exercise. The minimum performance for acceptable adherence was set so that the sessions should be performed at least on level 13 (hard) on the Borg scale for each exercise, 2 times per week.

Lymphedema status

Water displacement method (WDM): Arm volume was measured with the water displacement method which is used as the gold standard of limb volume measurements (13) and was described by Kettle (14). Bednarczyk et al (15) carried out a validity test for the method with a computerized limb volume measurement system and found a high correlation coefficient (r=0.992), and Sander et al (16) found ICC to be 0.99 for both inter- and intra-rater reliability.

Each arm was submerged in a container with water with the contralateral arm as the control on each occasion. The volume displacement was measured in grams and then converted into milliliters. The arm volume of the arm was expressed as total arm volume (TAV). Arm lymphedema, was defined as >5% excess volume compared to the contralateral arm (8) obtained by calculating the difference in volume between the affected arm and the contralateral arm. Arm lymphedema was expressed in milliliters as lymphedema absolute volume (LAV) and in percentage as lymphedema relative volume (LRV).

Bioelectrical impedance spectroscopy (BIS): Extracellular fluid in the arm was measured using a swept frequency bioelectrical impedance meter (model SFB3, SEAC Brisbane, Australia). The resistance at zero frequency, R_0, has been shown to be a reliable predictor of extracellular water (17). Using a multi-frequent current, R_0 can be estimated by extrapolation of the impedance data at higher frequencies, and changes in R_0 can be used to monitor changes in the extracellular fluid space (18). A tetrapolar electrode arrangement was applied using the equipotential principle to standardize the length of measured upper limb (19). The validity has been determined to $r_c = 0.92$ using inter-limb ratio for BIS (R_0 of unaffected arm/R_0 of affected arm; R_0 resistance at zero frequency) versus perometer (volume of

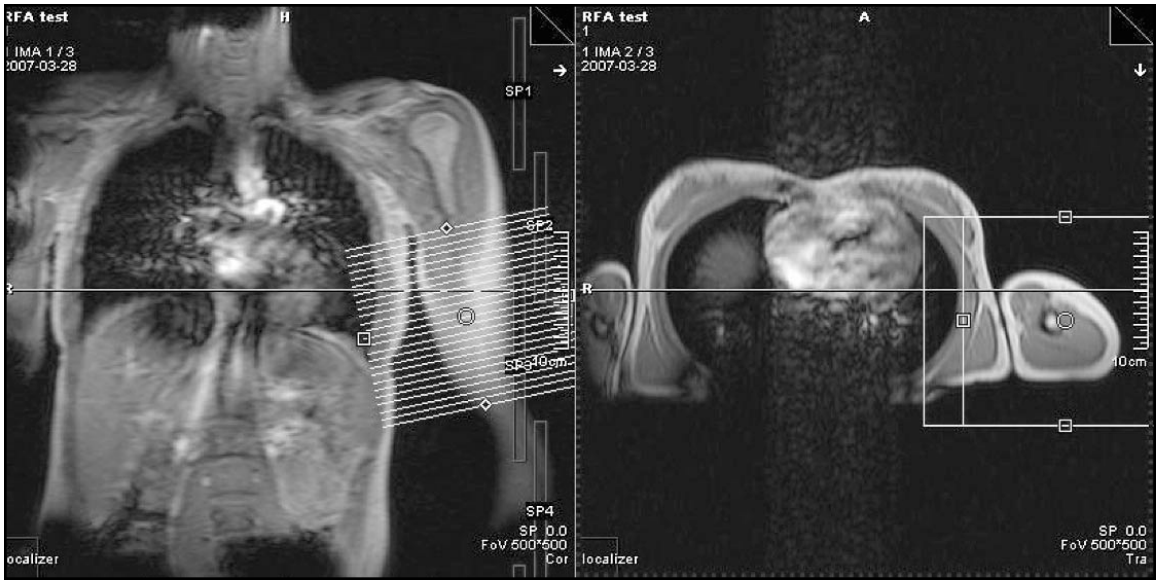

Fig. 2. MRI slices with a thickness of 5 mm and a distance between the slices of 1.5 mm were chosen representing the upper arm region between the axilla and elbow joint. The slices were localized using coronal (left) and axial (right) scout images. During evaluation, the slice presenting the lower m. deltoideus tendon attachment and the 11 slices distal of the first slice were included.

affected limb/volume of unaffected limb) and intrarater reliability showed ICC = 0.96 (0.93 to 0.98, 95% CI) (20).

All jewelry, watches, etc. were removed. Prior to the application of surface electrodes, the skin was cleaned with an alcohol wipe. With the patient lying supine on a bench with arms along her side, the electrodes were positioned on the upper limbs, in line with the ulna styloid and 5 cm distal of this spot, on the dorsum of the hands. One electrode was placed on the dorsal surface of the right foot over the third metatarsal bone. Both arms were measured, and the resistance at a frequency of 0 Hz (R_0) was estimated for each arm.

MRI: Images were obtained with the patient in a supine position using a Siemens Symphony 1.5 T (Siemens Medical Systems, Erlangen, Germany) with a large flex coil covering the upper arm. The field of view was 175 mm in the registered axial plane to ensure upper arm coverage. The images were T1-weighted to enhance anatomical information (fat is bright, muscle is greyish and water is dark). Twenty-five slices with a thickness of 5 mm and a distance between the slices of 1.5 mm were chosen representing the upper arm region between the axilla and elbow joint (*Fig. 2*). The slice at the level for lower m. deltoideus tendon attachment was identified as the first slice. The 11 consecutive slices located distally to this first slice were subsequently included in the study. A software program built in-house, using Matlab, was used for image analysis. Each slice was segmented into subcutaneous fat, muscle and bone/marrow. The pixel intensity distributions were used to discriminate fatty tissue and water in the subcutaneous fat. The volume of different tissues and water were calculated along the slice segments. Due to repositioning factors and the diffuse border between the muscle and fat segment, the CV for intrarater reliability are 2.5% in the subcutaneous fat segment and 4.7% in the muscle segment (own series in 4 patients).

Body weight was registered in kg on a scale with a precision of ±0.1 kg in order to verify changes in weight that could influence the arm volume.

Upper extremity status

Isometric muscle strength device (IMSD): Isometric shoulder muscle strength was measured with an electronic device connected to a strain gauge (Steve Strong HB, Växjö, Sweden) with a measuring range of 0-1999 Newton (N) and a precision of ±5N. A breaking force technique was used, which has been shown to be a reliable method (21). The technique was applied for shoulder flexors and adductors, and for elbow flexors and extensors, with the patient in a supine position.

Gripping strength was measured with a Jamar Hydraulic Hand Dynamometer with a range of 0-90 kp/cm^2. The instrument shows high concurrent validity (r = 1.0) tested with certified standard weights (22) and high intra/inter-rater reliability (ICC 0.85-0.98) (23). The measurements were performed with the patient in a sitting position, and the arm held close to the body with a 90-degrees flexion of the elbow.

All muscle strength measurements were repeated 3 times and the highest value was registered.

Disability of arm, hand and shoulder outcome questionnaire (DASH): To assess the disability of the upper-extremity, the Swedish version of The Disability of the Arm, Shoulder and Hand questionnaire (DASH) was used (24). DASH is a self-administrated region-specific instrument with a 30-item scale developed to measure upper extremity disability and symptoms. Each item is scored on a 1 to 5-point scale. The total score of all items are used to calculate a composite score called the DASH score, ranging from 0 (no disability) to 100 (most severe disability) (25). The Swedish version has been tested for cultural adaption and showed high internal consistency (Cronbach alpha 0.96) and high test-retest reliability (ICC 0.92) in patients with upper-extremity orthopedic conditions (24). A 10-point difference in mean DASH score is considered as a minimal clinically important change (26).

Log book

Adherence to the program was controlled every fortnight by reviewing the log book kept by each patient to register date, weights, use of compression sleeve and perceived exertion on:

The Borg scale: A scale that measures the patient's perceived exertion. The scale ranges from 6 (minimum) to 20 (maximum), where every other step is provided with a verbal statement (24).

Measurement procedure and safety

Arm volume (WDM), extracellular fluid (BIS), muscle strength (IMSD and gripping strength), arm shoulder and hand disability (DASH) and body weight were measured at the beginning of the control period and at the start and end of the intervention (*Fig. 1*). In addition, arm volume was measured every fortnight to check for volume increase > 5% compared to the total arm volume at the start of the intervention period, in case the patient dropped out and was offered immediate treatment. Also, other symptoms of worsening of the lymphedema, like increased experience of tension and heaviness in the arm or increase of hand edema, were considered reasons for drop-out. Images (MRI) of the upper arm were obtained in the first ten patients at the beginning of the control period and at the start and end of the intervention in order to determine whether any increase of arm volume might be caused by an increase in muscle mass or in fluid.

No exercises were performed before measurements on the same day as measurements were taken.

TABLE 1
Patient Characteristics of the Total Intervention Group (n=23) and of the Patients with Additional MRI (n=10)

	Total group n=23	Additional MRI n=10
Age (years, mean±SD)	58 ± 8	57±8
Body mass index (mean±SD)	25.8±3.2	26.2±2.9
Breast cancer treatment		
Mastectomy/partial mastectomy, n (%)	19/4 (83/17)	8/2 (80/20)
Nodes removed (n, mean±SD)	14±6	14±4
Radiation none/breast only/breast and axilla, n (%)	3/7/13 (13/30/57)	1/2/7 (10/20/70)
Surgery on dominant side, n (%)	13 (57)	5 (50)
Lymphedema status		
Edema duration*, months, mean±SD	100 ± 87	97.7±6.4
Excess volume, LAV ml	456 ± 279	342±211
LRV %	19.6 ± 11.7	15±7

*Time from lymphedema onset to time for the study
LAV = Lymphedema absolute volume; difference between arms in milliliters
LRV = Lymphedema relative volume; difference between arms in percentage

Statistics

Descriptive statistics of variables include rates for binary variables and mean and standard deviation for continuous variables. Pre-intervention variables for continuous data were calculated as a mean of the pre- and post-control period values.

Comparisons of pre-intervention versus post-intervention values for continuous variables were made using a non-parametric test, the related samples Wilcoxon sign rank test, for continuous variables, since the patient group was small and values did not exhibit Gaussian distribution. All p-values are presented and a level of $p<0.05$ was chosen to indicate statistical significance.

All statistical analyses were performed using IBM SPSS Statistics 21.

RESULTS

Feasibility: Retention and Adverse Events

Twenty-six patients were included in the study. Three patients dropped out during the 4-week introduction program, one due to pneumonia, one because of pain in the arm during the first week of exercise, and one due to swelling of the hand that later on developed into an increased arm volume >5% compared to the total arm volume at start of the introduction. The last two were considered to be adverse events related to the exercises.

Feasibility: Adherence

All patients fulfilling the 8-week intervention program (n=23) performed the minimum criteria set for the intervention. Nineteen of the patients completed all 3 sessions weekly for all 8 weeks. Four patients performed 2 sessions weekly for 1-3 weeks and 3 sessions weekly for the rest of the 8 weeks.

Patient Characteristics

Table 1 shows baseline characteristics of the 23 patients that completed the intervention.

TABLE 2
Muscle Strength, DASH Score, Total Arm Volume, Excess Volume (n=23) and Tissue Fluid (n=16) in Patients With Breast Cancer-Related Arm Lymphedema at the Start and End of the 12-Weeks Intervention Program

Muscle groups	Pre-intervention mean±SD	Post-intervention mean±SD	p-value
Shoulder flexors (N)	185±37	199±36	0.001
Shoulder adductors (N)	138±30	155±27	0.001
Elbow flexors (N)	214±33	227±33	0.003
Elbow extensors (N)	141±25	154±27	0.002
Gripping force (kp/cm^2)	36.5±9.3	37.8±9.2	0.059
DASH score	11.4±9.1	10.2±11.0	0.29
TAV (ml)			
Edema arm	2771±495	2772±491	0.32
Healthy arm	2322±333	2345±311	0.1
LAV (ml)	448±278	427±287	0.03
LRV (%)	19.2±11.6	18.0±11.7	0.005
BIS (ratio)	0.87±0.1	0.89±0.1	0.069

N = Newton; DASH = Disability of arm, shoulder and hand questionnaire; TAV = Total arm volume; LAV = Lymphedema absolute volume; difference between arms in milliliters; LRV = Lymphedema relative volume; difference between arms in percentage; BIS ratio = Tissue fluid as ratio between arms

All of them had had axillary node dissection. During the intervention, all patients had been wearing a compression sleeve according to their usual procedures, which was at least daily. All patients also chose to wear a compression sleeve during exercise.

Images by MRI were obtained in the first 10 patients from Skane University Hospital. This group (n=10) did not differ from the total group (n=23) concerning baseline characteristics (*Table 1*).

Lymphedema Status

All patients included in the intervention (n=23) had arm lymphedema with a mean lymphedema relative volume (LRV) of 19.6 ± 11.7% at the start of the control period. At the start of the introduction, LRV was 19.0 ± 11.7% (range 5.1-53.5%).

During the control period, there were no significant changes for the TAV of each arm, LAV or LRV measured by WDM, or for the BIS ratio. After the intervention there was a reduction of the LAV, LRV and a tendency towards reduction of BIS ratio (p=0.069) compared to at the start of the intervention. No significant change of TAV was found in the lymphedema arm or in the healthy arm (*Table 2*).

Mean ± SD body weight was 71.4 ± 10.0 kg for all patients and 71.7 ± 10.1 for the MRI group at start of the control period and did not change during the intervention.

Similar to the total group (n=23), the MRI group (n=10) showed a reduction of BIS ratio and a tendency to reduction in LAV and LRV after intervention. The results also showed a tendency towards reduction of fat (p=0.067) in the upper arm of both arms after intervention (*Table 3*).

Upper Extremity Status

The shoulder and arm strength did not change during the control period but increased significantly in all four shoulder and arm muscle groups after intervention, and showed a tendency towards an increase in gripping strength (p=0.059). No changes

TABLE 3
Total Arm Volume and Excess Volume Measured by Water Displacement Method, Tissue Fluid Measured by Bioimpedance and Fat, Water and Muscle Measured by MRI in Patients with Breast Cancer-Related Arm Lymphedema at the Start and End of Intervention (n=10)

		Start of intervention mean±SD	End of intervention mean±SD	p-value
Water displacement method				
TAV (ml)				
Edema arm		2630±461	2623±464	0.878
Healthy arm		2261±299	2277±299	0.445
LAV (ml)		370±218	343±226	0.093
LRV (%)		16.2±8.1	14.8±8.3	0.059
Bioelectrical impedance spectroscopy				
BIS ratio		0.83±0.10	0.86±0.11	0.050
MRI (mm)				
Fat	Edema arm	288±97	268±98	0.069
	Healthy arm	241±89	226±79	0.059
Water	Edema arm	21±10	21±13	0.401
	Healthy arm	15±6	13±8	0.169
Muscle	Edema arm	219±37	223±28	0.207
	Healthy arm	224±41	224±31	0.445

TAV = Total arm volume; LAV = Lymphedema absolute volume; difference between arms in milliliters; LRV = Lymphedema relative volume; difference between arms in percentage; BIS ratio = Tissue fluid as ratio between arms

were found in the DASH score after intervention (*Table 2*).

Log Book

The mean ± SD (range) weight resistance during the introduction period (week 3) was 1.6 ± 0.6 (0.5-3.0) kg for long-lever arm (exercise I and II) and 2.3 ± 0.8 (1.0-4.0) kg for short-lever arm (exercise III and IV) with the mean rating of perceived exertion being about 13 (somewhat hard) on the Borg scale. During the last week of the intervention period, the mean ± SD (range) weight resistance levels were 3.0 ± 1.0 (1.0-5.5) kilograms for long-lever arm and 4.1 ± 1.7 (2.0-9.0) kilogram for short-lever arm. The rating of perceived exertion on Borg's scale the last week of intervention approached 17 (very hard) and was rated in mean 16.4 ± 0.6 (range 13-19) during the 8-week full intervention.

DISCUSSION

In this pilot study we found that a 12-week home-based weight-lifting program is feasible and relatively safe. A significant increase of shoulder and arm muscle strength was found and results also supported other studies showing that weight lifting exercises can be performed without worsening of the lymphedema. Results also indicate that regular exercise may even reduce excess volume and fat tissue.

Recruitment and Subjects

The recruitment of the patients was made through the register of two Lymphedema Units assuring that a variety of patients fulfilling the inclusion criteria were approached, not only those particularly interested in exercise, but also those who provided different reasons for not taking part. We believe this procedure is more likely to reflect the total breast cancer population than recruitment through, for example, advertisement.

One of the inclusion criteria was an age of less than 70 years. Some studies have shown that older persons can exercise and increase their strength with no problems (28). However, our experience from prior studies is that older patients are more likely to drop-out. This may be because breast cancer patients also suffer from other impairments like stiffness and pain, which sometimes reduces their ability to carry through a physically taxing study. However, this does not mean that elderly breast cancer patients cannot do muscle strengthening exercises, but rather, the exercises should be adjusted to suit individual capacity just as in healthy elderly persons.

Feasibility

As we could not foresee the feasibility of the planned study, both regarding the administration and the number of patients being able to complete the intervention program, we chose to perform a pilot study. However, we also chose to include a control period, meaning that the patients were their own controls during two weeks. The aim of this procedure was mainly to assure that there was no bias from the normal biological volume fluctuations (29) and make sure that a steady arm volume could be maintained. This kind of design does not reach the scientific level of a randomized controlled trial, but may ascertain that no major bias will interfere with the results.

Feasibility is shown both in that it can be satisfactorily administered and that the patients can be recruited and retained with high adherence (100%) to the intervention. The high adherence to the intervention program indicated that there were no major problems carrying it through for the patients, but the patients' experiences of the program administration and intervention were not evaluated. However, possible advantages can be the ability to choose when and where to exercise, and not having to perform in a group setting or in any way together with others. This was also supported by the fact that only two out of eleven patients who declined to take part claimed that lack of time was their reason. The rest of these patients (n=9) did not have time to attend to the measurement procedure but may very well have been able to carry through the intervention.

The safety of the program is relatively high, and no adverse events were reported during the full intervention period. However, during the introduction period, starting with a load of 50% of 10RM and ending with completed 10RM, two adverse events appeared. One was an increased swelling of the hand. The other was aching in the entire affected arm when repeating arm lifting with weights suggesting a neurological problem, however, this was never examined. These two events indicate that a regular follow-up of the patients should be done in particular during the first weeks of the program. Though based on a small amount of material, we still recommend that special focus be put on small signs of increasing lymphedema, in case the patient could be recommended to come for a check-up every fortnight, similar to this study. If there are no signs of increasing lymphedema or even a reduction during the first weeks, the frequency of follow-ups further on might be less.

Lymphedema Status and Subcutaneous Fat

Swedborg et al (29) has demonstrated

that, without a compression garment, there is normal biological fluctuation of the healthy arm volume over a fortnight. To be able to keep a steady volume during the study period the women were wearing a new compression garment, not only during the control and intervention period but also at least one month prior to the start of the study. This procedure was applied to assure that old, insufficient compression garments would not influence the arm volume results during the study. Results show that there were no significant changes in arm volume during the control period in the lymphedema arm or in the healthy arm, indicating that volume changes were not influenced by insufficient garments or normal fluctuations.

Images (MRI) of the upper arm were obtained in order to determine whether any increase of arm volume during intervention might be caused by increase in muscle mass or fluid. As no significant increase in arm volume was found in the first ten patients no further examinations were performed due to practical reasons (*Table 3*).Upon analysis of images, a tendency towards reduction of fat in both arms was found, but there was no change in body weight to support this finding. However, this discrepancy could possibly have been clarified by a RCT, adequately powered. Still, even more important seems to be the need for a test of validation and reliability in MRI measurements for lymphedema status, and responsiveness to lymphedema treatment outcome.

Both arms increased (not significantly) after the intervention; however, the healthy arm increased more than the edematous arm, resulting in a significant reduction of excess volume (*Table 2*). It is hard to determine what made the arms increase, as MRI did not show any increase of muscle mass or water, but a reduction of fat on both sides that may have reduced the arm volume. Though MRI is used for diagnosis of lymphedema, test of validity for measurement of water/tissue fluid has not been performed. However, in this study it was possible to show a difference in water content between the affected and non-affected arm (p=0.007). An intra-rater reliability test was also made within this study. However, it only included 4 patients, and results from the test may therefore be limited. Nor has the responsiveness of MRI to detect changes in water/tissue fluid after intervention been evaluated.

Whatever the cause of the increase, the lesser increase in the edematous arm compared to the healthy arm may have been due to the compression sleeve, and the reduction of excess volume may not have occurred if the sleeve had not been worn at least daily and also during the exercise sessions.

The tendency towards less subcutaneous fat in the arms, but without body weight reduction, may indicate a local fat reduction. It has been discussed for many years whether specific exercises can reduce local adipose tissue depots, i.e., induce a “spot reduction” of adipose tissue, and thus modify fat distribution (29,30). Olsen and Edelstein (30) found a decrease in skinfold thickness of the trained arm compared to the untrained arm. The local fat reduction was supported in another, more recent study (31) where male subjects perform single-leg extensions with light weight for 30 consecutive minutes. An increase in blood flow and lipolysis were observed in the exercising leg when compared to the resting leg. The study suggested that during exercise, body fat is preferentially used from the area being trained (31). If “spot reduction” can be established, it could mean a lot for the effort to try to reduce induration of fat found in long-standing lymphedema, otherwise requiring surgical treatment (32). In that case a RCT examining the influence of weight-lifting on local fat tissue in lymphedema patients could be performed.

Upper Extremity Strength and Disability

The increase of strength in all muscle groups measured after intervention was a clear indication that the load of weights had

been high enough. This was supported by the patient's own experience of exertion assessed on the Borg scale as the mean value at the end of the intervention was about 17, meaning the patients experienced the exertion as very hard. The experience of exertion and knowledge of the value assigned on a scale is informative to patients, because it provides them with evidence as to the size of the load that is attainable for them in daily life. However, it is essential for safety that patients start at an exertion level lower than their peak attainable level and then work their way up, which is the same advice given to inactive but otherwise healthy persons.

In a systematic review of exercise in patients with lymphedema it was stated that strong evidence is available regarding the safety of resistance exercise without risk of development or exacerbation of breast cancer-related lymphedema (7). However, to our knowledge, Schmitz et al (33) are the only group that has published data on the load of weights. Their protocol included a gradual increase in weight on both arms by doing bench presses with a mean weight of 24 kp (53 lbs) during 6 months. This weight is similar to our findings from corresponding weight-lifting for elbow extension in a supine position. The lifting was one-handed, that is one dumbbell in each hand, and showed a mean of 15 kp for each arm after 12 weeks of intervention. Both studies showed a significant increase of strength without any deterioration of the arm lymphedema. However, the study by Schmitz et al (33) was a large (n=141) randomized study while the present study was a pilot study. Still, the present pilot study provides data for recommendations to the patients concerning weight resistance level. Compared to the study by Schmitz et al (33), the present study also shows that the same amount of weights can be distributed at home without going to a special location, like a gym.

Another interesting finding is that grip strength increased though the hand and wrist muscle were not the target for the special exercises. However, dumbbells need to be stabilized by hand and wrist in particular by the exercises with long lever arm, and gripping strength may have improved by this need of stabilization.

All patients chose to wear garments. We did not evaluate why they made this choice but a former study found that many patients reported that the sleeve gave support when weight-lifting (11).

The DASH score was found to be very low, with a mean of 11.4 and maximum range at 35 at the start of the intervention, compared to a group of breast cancer patients (n=50) also with axillary node dissection and arm lymphedema with a score of 36.6 (34). The difference may be explained by the exclusion criteria of the present study not accepting e.g., patients with pain. Because of the low DASH score, the potential to improve the DASH score was limited. However, several patients expressed spontaneously that they felt stronger in the shoulder and arm, and some used the expression "my arm feels normal again."

In practice, it is likely that the most important issue for the patients is to focus on the 10RM system and to be well-informed about increasing resistance when they are able to do more. This should automatically lead to the experience of high exertion. The amount of weights will then turn out to be of less importance, but can provide stimulation and an individual challenge.

CONCLUSION

The findings of this pilot study show that a home-based weight-lifting program for patients with breast cancer-related lymphedema is feasible and relatively safe. The results of the program show increased arm and shoulder strength, without any deterioration of the lymphedema but a small reduction of the excess volume and, in a smaller group, a tendency towards reduction of fat tissue in the upper arm. A regular follow-up with control of lymphedema

symptoms is recommended at least during the first weeks of the program.

The findings can be used to inform the development of RCT, adequately powered, to evaluate home-based compared to supervised exercise programs with a range of outcomes including shoulder and arm strength, arm lymphedema status and local subcutaneous fat distribution.

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