WEIGHT-BEARING EXERCISE AND ITS IMPACT ON ARM LYMPHOEDEMA

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Abstract

Background: There is conflicting information about whether weight-bearing exercises can make lymphoedema worse. *Aims:* To evaluate the influence of a programme of weight-bearing exercises on the severity of arm lymphoedema. *Methods:* Eighteen women with breast cancer-related arm lymphoedema took part in a stepped weight-bearing exercise programme. After each session, perceived exertion was rated on a Borg scale. The arm volume (TAV) was measured by water displacement (and multifrequency bioimpedance analysis [MFBIA]), and the patients' experiences of tightness and heaviness were measured on a 10-point scale. All measurements were made before and after training and 30 minutes and 24 hours after the end of the sessions. *Results:* A statistically significant increase of lymphoedema absolute volume (LAV) was measured immediately after exercise. There was also a tendency towards an increase in TAV and lymphoedema relative volume (LRV). MFBIA showed a tendency towards increase in LRV 30 minutes after training. The TAV, LAV and LRV returned to pre-training values after 24 hours and TAV showed a tendency to reduce, supported by the subjective assessments. *Conclusions:* A controlled short-duration arm exercise programme with increasing weights does not increase lymphoedema arm volume. *Declaration of interest:* This study was supported by research grants from the Swedish Cancer Foundation.

Key words

Arm lymphoedema
Breast cancer
Weight-bearing exercise

Breast cancer is the most common form of cancer in women in Western countries (McPherson et al, 2000, Surveillance, Epidemiology and End Results, 2003). Most patients will have a combination of treatments to control the disease locally, with surgery often being combined with radiotherapy. Arm lymphoedema, and a reduced range of movement and muscle strength in the shoulder are well-known side-effects of these treatments (Johansson et al, 2001). As a result of earlier diagnoses and improved treatment, the survival rate for people with breast cancer is increasing (Talbäck et al, 2003, National Institutes of Health, 2006). Improved treatment has also increased survival time following recurrence (Bergh et al, 2001). This has led to more and more women suffering from a range of comorbidities related to cancer treatment, including lymphoedema.

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Breast cancer-related arm lymphoedema is chronic swelling caused by axillary node dissection with or without adjuvant radiotherapy. The incidence of arm lymphoedema depends on its definition. Breast cancer-related lymphoedema has been defined as the affected arm being 10% larger than the contralateral arm (Swedborg, 1977). The incidence is about 10% when axillary node dissection is performed, and about 40% when axillary radiotherapy is added (Johansson et al, 2001; Nagel et al, 2003). The incidence for the last group can be expected to remain unchanged but there are reports of little, if any, lymphoedema for people who have a negative sentinel lymph node biopsy result (Mathew et al, 2006).

There are two potential sources of breast cancer oedema formation: lymph drainage failure and haemodynamic imbalance (Svensson et al, 1994a; b). Treatment of lymphoedema is focused on the lymphatic system and failure to acknowledge the contribution of both lymphatic and vascular mechanisms can lead to a limited view of possible treatment options, particularly physical training.

Reduced arm muscle strength in 15–25% of patients treated for breast cancer has been reported (Hladiuk et al, 1992; Maunsell et al, 1993). This may be related to reduced nerve impulses to the muscle, as a result of nerve entrapment following axillary surgery and irradiation (Höjris et al, 2000). Pain has been reported in 20–50% of patients (Bruce et al, 2004; Rothemund et al, 2004) which can lead to inactivity. However, reduced muscle activity may also follow because patients are advised by healthcare professionals to avoid heavy work or vigorous arm exercises.

An increased level of activity associated with exercise may reduce body weight and increase the shoulder's range of motion (Wingate et al, 1989) and improve muscle strength. It also has the potential to facilitate lymphoedema control by resetting the sympathetic tone of the lymphatic vessels (Roddie, 1990) and activate lymph flow (Olszewski and Engeset, 1980). Additionally, physical activity affects the production, metabolism and excretion of hormones that may be linked to a lower risk of breast cancer (Thune et al, 1997), and recurrence of the disease (Holmes et al, 2005).

It has also been demonstrated that women who exercise aerobically or walk during radiotherapy or chemotherapy treatment for breast cancer, increase their maximum oxygen uptake and feel less fatigued (Galvão and Newton, 2005). Nevertheless, women with breast cancer-related arm lymphoedema are advised by healthcare professionals to avoid using the affected arm for heavy work so as not to overload the lymphatic system. At the same time, women are instructed to generally perform basic arm movements and sometimes tai chi-type exercises in order to stimulate the system. This can be confusing for the patient who is unable to get clear instructions as to what amounts to 'good' and 'bad' exercise, and this requires clarification.

Knowledge about the influence of exercise and work-related activity on arm lymphoedema is sparse. A few small studies suggest that moderate, as well as heavy, controlled physical activity does not increase the risk of precipitating or worsening lymphoedema (Harris and Niesen-Vertommen, 2000; McKenzie and Kalda, 2003; Lane et al, 2005). This relationship needs to be examined more carefully, considering the basic factors (mode, frequency, duration and intensity) of training programmes, as well as patients' reactions to these programmes (Wilmore and Costill, 2004).

Studies have stated that vigorous arm exercise can be performed without precipitating lymphoedema (Harris and Niesen-Vertommen, 2000; Ahmed et al 2006). In fact, reduction in sporting activities after breast cancer treatment has been reported to increase the risk of developing arm lymphoedema (Johansson et al, 2001).

Johansson et al (2005) showed that low-intensity exercises with weights increased the total volume of the arm immediately after training in healthy people, as well as in people with lymphoedema of the arm, whether the exercises were performed with or without a compression sleeve. Importantly, however, the volume returned to pre-exercise level the following day when the patients had worn their compression sleeve, at least during the day or during the day and the night, according to their usual procedures during the previous three months.

The aim of this study was to evaluate the impact of a high level of programmed physical activity subjectively experienced as exertion, on the volume of arm lymphoedema in patients who did not wear a compression sleeve during or after the exercise programme. The authors were interested to find out whether the volume of the lymphoedema in the arm changed when patients do not wear a compression sleeve at all, and whether the exercise load can be increased to a high-intensity level without increasing the volume of lymphoedema.

Methods

Eighteen women with breast cancer-related arm lymphoedema from the lymphoedema assessment clinic, Flinders Medical Centre, Adelaide, South Australia, were recruited to the study.

The inclusion criteria were: age ≤70 years, arm volume difference 5–29% for at least six months, and not having worn a compression sleeve on the affected arm for at least six months. The exclusion criteria were: previous contralateral breast disease, recurrent cancer, dementia and intercurrent disease that could cause swelling in the body or affect muscle strength including painful diseases such as tendonitis, rheumatoid arthritis and fibromyalgia. The demographic data are presented in *Table 1*.

The study was approved by the Flinders Medical Centre clinical research ethics committee.

Measurements

Arm fluids

Arm fluids were measured using multifrequency bioimpedance analysis (MFBIA) with electrodes applied to the fingers, thumbs, ball and heel of the feet (*Figure 1*). The machine was an InBody 3.0 system (Biospace, Seoul, Korea). This system is a multifrequency and segmental analyser (5–500khz), where the participant stands erect on the foot plates and holds the other, resulting in eight contact points. This helps eliminate discrepancies in electrode placement and location, which can occur in the traditional four electrode placement system, although the negative aspect of this device is the fact that the arms are measured in the dependent position and not the supine one, as occurs with

Table 1

Characteristics of the study group (*n*=18)

	Mean	±SD
Age (years)	58	±11
Oedema duration (months)	54	±49
Oedema volume		
LAV (ml)	585	±389
LRV (%)	25.6	±18
Heaviness score as rated by patient (max 100)	41	±26
Tightness score as rated by patient (max 100)	38	±26
Cancer treatment		
Surgery, site, right/left	10/8	
Side, dominant/ non-dominant	11/7	
Type, partial/ mastectomy	6/12	
Radiotherapy	10	
Chemotherapy	10	

the Impedimed system (Queensland, Australia).

The multifrequency technique quantifies total fluids (intracellular and extracelluar) in the extremities and trunk, easily distinguishing any gain or loss of fluid from fat and muscle changes (Mikes et al, 1999). Other studies (Cornish et al, 2001; Hayes et al, 2005) have evaluated bioimpedance as a reliable and accurate technique for measuring even small changes in extracellular fluids in patients with lymphoedema.

Arm volume

Arm volume was measured using the water-displacement method (WDM) (according to Archimedes' principle), which is considered the gold standard of measuring limb volume (Bernas et al, 1996). This method has been described by Kettle et al (1958), who found a standard deviation of 1.5% from the mean volume of repeated measurements. Bednarczyk et al (1992) carried out a validity test for the water displacement method with a computerised limb volume measurement system (CLEMS) and found a high correlation coefficient (*r*=0.992). They also showed that when measuring plaster figures, CLEMS had a high test–retest correlation (*r*=0.999).

Figure 1. Arm fluids measurement with multifrequency bioimpedance with eight contact points.

A cylindrical container with a soft drainpipe 45cm above the bottom was filled with water. Each arm was submerged in a straight position with the fist and the proximal phalanges resting at the bottom. The water displacement was collected in a tank and weighed in grams, with a precision of 5g and translated into millilitres, assuming water has a density of 1g/ml (*Figure 2*). The contralateral arm was used as a control. Multiple measurements were made on each occasion and averages were recorded.

The lymphoedema absolute volume (LAV) was obtained by calculating the difference in volume between the arm with lymphoedema and the contralateral arm (Bernas et al, 1996). The lymphoedema relative volume (LRV), which took build into account, was defined as an increase in volume of at least 5% compared with the unaffected arm (Stanton et al, 2006) using the following formula:

$$\frac{\text{Volume lymphoedema arm} - \text{volume contralateral arm}}{\text{Volume contralateral arm}} \times 100$$

Subjective assessment

The experiences of heaviness and tightness in the affected arm while standing with arms hanging, which are common sensations associated with lymphoedema (Swedborg et al, 1981), were each scored by the patient on a horizontal 0–10-point graphic rating scale, where 0 equated to no symptoms and 10 was related to the worst imaginable. The subjective assessments were scored before exercise and on three occasions after exercise. On these three occasions, the patients were allowed to see what they had scored before exercise in order to assess whether the sensations at each of the subsequent occasions were more or less similar. This approach to scoring has been tested by Scott and Huskisson (1979) and used in previous studies about arm lymphoedema (Johansson et al, 1998; 1999; 2005).

Perceived exertion

The Borg scale was used for the patients' rating of perceived exertion after physical exercise. The scale is a validated and reliable indicator in monitoring an individual's exercise tolerance. It ranges from a rating of six (minimum exertion) to 20 (maximum exertion), where every second step was provided with a verbal statement from 'very, very light' to 'very, very hard' (Borg, 1982; American College of Sports Medicine, 2000).

Exercise programme

A specially designed arm exercise programme, derived from a clinically devised weight-lifting programme (Miller, 1998), which has also been used in a previous study (Johansson et al, 2005), was used. This study examined low intensity resistance exercise for patients with breast cancer-related arm lymphoedema. Five different exercises, i.e. shoulder flexion, abduction in the standing position and adduction in the supine position, elbow extension in the supine position and flexion in the sitting position were each performed 10 times in the following order:

- Long-lever arm: shoulder flexion and abduction in the standing position and adduction in the supine position
- Short-lever arm: elbow extension in the supine position and flexion in the sitting position.

A session involved 10 cycles of each activity.

Study design

After the arm volume difference had been established, the exercise programme started with one session, i.e. 10 x 5 activities of shoulder flexion, abduction and adduction with 0.5kg weights in each hand, followed by elbow extension and flexion with 1kg weights in each hand. The patient's rating of perceived exertion followed each session. The activities were repeated with a graded increase in weights at each new session (with a maximum of five sessions), until the patient's rating exceeded 15 (strenuous) or more on the Borg scale. The maximum weight was 2kg for the long-lever arm and 3kg for the short-lever arm. There was a three-minute pause between each session. Measurements of arm fluids, arm volume and subjective assessment of heaviness and tightness in the arm were performed before, immediately after, 30 minutes after and 24 hours after exercise.

Statistics

The Wilcoxon signed rank test (a non-parametric paired test) was chosen because of the small study group. The $p \leq 0.05$ significance level was chosen but $p \leq 0.1$ are also presented.

Results

Sixteen patients finished at least three sessions that rated 17 (very hard) on the Borg scale and five patients performed all five sessions (*Table 2*).

The results from measurement with MFBIA, WDM and graphic rating scale are presented in *Table 3*. A statistically significant ($p<0.05$) increase of LAV was measured by MFBIA immediately after the exercise programme. There was also a trend ($p=0.08$) for TAV and LRV to increase when measured the same way. In addition, MFBIA measurements showed an increase for LAV and LRV, 30 minutes after training ($p=0.09$).

Twenty-four hours after training the TAV, LAV and LRV (measured by MFBIA) returned to pre-training values, and TAV (measured with WDM) showed a tendency towards reduction ($p=0.1$), although this was not statistically significant. The patients' assessment of subjective experiences showed a statistically significant reduction of heaviness ($p \leq 0.05$) and tension ($p \leq 0.01$) 24 hours after training. It was therefore concluded that exercises with heavy weights do not worsen breast cancer-related arm lymphoedema.

Discussion

The aim of this study was to show the impact of heavy physical activity on arm lymphoedema following treatment for breast cancer. What we had anticipated, based on anecdotal and other published reports, was that there would be an increase or no change to the lymphoedema. Interestingly, however, the results of the volume measurements indicated a trend towards reduction of the arm lymphoedema the day after the heavy exercises had been performed, and the patients' own subjective assessments supported this trend.

These results, together with other studies (Harris and Niesen-Vertommen, 2000; McKenzie and Kalda, 2003; Lane et al, 2005, Ahmed 2006), question the long tradition of recommending only movement training, or no training at all for the arm in patients with lymphoedema. This tradition has been built on empiricism but with little substantial scientific evidence. We believe this may have caused significant suffering to women being unable to work or perform muscle-strengthening exercises which are part of many sports and other activities.

Considering recently published findings (Holmes et al, 2005) showing that physical activity can reduce recurrence of breast cancer, the importance of evidence-based training instructions for these patients is essential. An additional benefit of exercise is the possibility of reducing obesity, which has been identified as a risk factor in the development of lymphoedema (Johansson et al, 2002; Goffman et al, 2004).

The fact that the patients were able to perform the heavy exercises may come as a surprise. However, it was not a surprise to the authors having met several patients in the clinic who had not obeyed the restrictions on strenuous work activity, as they had the strong conviction that even strenuous exercises were generally good for them. Our anecdotal experience, as well as that of the patients, was that the lymphoedema had not worsened.

The small increase in the arm fluid immediately after the exercise sessions was also expected as a volume increase had been shown in a previous study (Johansson et al, 2005). What was not expected was the tendency towards reduction of the arm lymphoedema the following day, as this has not been reported in any previous study.

Importantly, in the other exercise studies, the women had worn compression sleeves. When worn they can be an effective treatment component (Johansson et al, 1998, 1999; Brorson and Svensson, 1998); therefore, it was interesting to see how patients fared without them, as

Figure 2. Arm volume measurement with water displacement method.

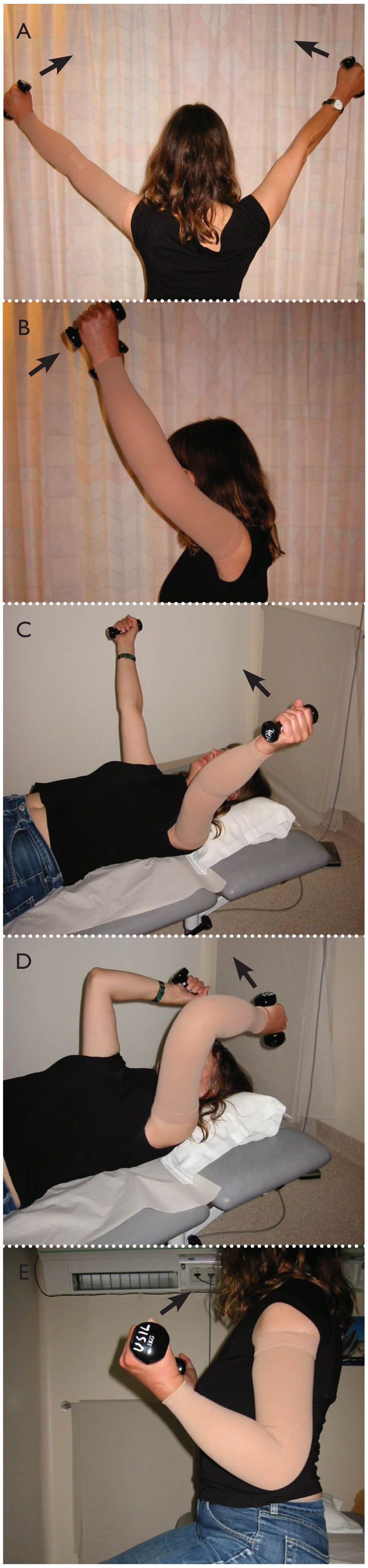

Figure 3. Arm exercise programme with weights. In the standing position, shoulder abduction (A) and flexion (B). In the supine position, shoulder adduction (C) and elbow extension (D) and, in the sitting position, elbow flexion (E).

in this study. Compared to a previous study examining low intensity resistance exercise with or without a compression garment (Johansson et al, 2005), a similar pattern was seen in both studies; that is, increase of volume immediately after exercise but a return to pre-exercise values after 24 hours with a tendency towards volume reduction. The reasons for the volume increase and the influence of compression garments are discussed by the authors in the previous study (Johansson et al, 2005).

Before anyone with arm lymphoedema undertakes any exercise or activity or return-to-work programme, we recommend an assessment by a trained healthcare professional, as every person will have a different response to exercise and activity. We suggest that such an assessment could be carried out in a similar way to that reported in this study.

In our study, several different measurement methods were used to show the effect of high-intensity training on arm volumes, which supported findings of earlier studies that had used similar techniques. More modern opto-electronic and bioimpedance techniques were also used. The WDM is regarded as the gold standard for the measurement of arm volume (Bernas et al, 1996). The arm volume changes in this study are not only statistically important, but also likely to have practical and biological significance, which is why we also report on the non-statistical changes.

The patients reported reduction in heaviness and tightness of the arm 24 hours after exercise, but this does not seem to be associated with any volume changes. Still the *p*-value ($p=0.1$) for total arm volume reveals a tendency towards reduction of arm volume the following day and therefore may support the subjective assessment. The feeling of heaviness correlates to the volume of arm lymphoedema (Swedborg et al, 1981), and this may add further strength to our findings of objective and subjective improvements in the limb following a significant programme of physical activity.

Although not measured, none of the patients complained about delayed onset muscle soreness the following day, although 24 hours may have been too short a time to evaluate this side-effect.

The major limitation of the study was that it was a small pilot trial which aimed to inform further studies and, therefore, obtaining statistically significant results was difficult. Further, the allocation of the patients to the study was not random and nor was there a control group with which to compare results.

Table 2

Stepwise increase of weights at each session of the exercise programme ($n=18$)

Session	Long/short-lever arm weights (kg)	Number of patients who felt exerted at this level	Borg scale median score
1	0.5/1.0	0	-
2	0.75/1.5	2	15.5
3	1.0/2.0	4	17
4	1.5/2.5	7	17
5	2.0/3.0	5	15

Table 3

Means ± standard deviations of arm fluid measured by multifrequency bioimpedance analysis (MFBIA), arm volume measured by water displacement method (WDM) and subjective assessment of heaviness and tightness in the arm measured by a graphic rating scale in patients with breast cancer-related arm lymphoedema (*n*=18) before, immediately after, 30 minutes after and 24 hours after high intensity resistance training. Pre-exercise data were compared to each of the post-exercise data

	Before exercise	Immediately after exercise	30 minutes after exercise	24 hours after exercise
Arm fluid — measured with MFBIA				
Total arm volume (ml)	2187±532	2211±552 (p=0.08)	2173±558	2196±532
Lymphoedema absolute volume (ml)	457±439	471±453 ($p\leq 0.05$)	473±453 (p=0.09)	452±436
Lymphoedema relative volume (%)	27±26	28±27 (p=0.08)	29±27 (p=0.09)	27±26
Arm volume — measured using WDM				
Total arm volume (ml)	2969±679	2968±684	2957±677	2953±686 (p=0.1)
Lymphoedema absolute volume (ml)	585±389	582±396	586±391	577±395
Lymphoedema relative volume (%)	26±18	26±18	26±18	25±18
Subjective assessment				
Heaviness (cm)	4.1±2.6	4.1±2.6	3.8±2.4	3.1±2.0 ($p\leq 0.05$)
Tightness (cm)	3.8±2.6	3.3±2.5	3.3±2.5	2.6±2.2 ($p\leq 0.01$)

Further work is needed in this area; in particular, muscle strength training with weights during a longer period in order to increase arm strength without worsening lymphoedema. These findings do suggest that for some patients physical activity, even at a strenuous level, does not worsen (and in fact may improve) lymphoedema.

Conclusion

This controlled, short-duration arm exercise programme with increasing weights did not increase lymphoedema arm volume at the 24-hour follow-up among the study group. However, there was a small but significant increase in lymphoedema arm fluid immediately after exercise which returned to pre-exercise levels by 24 hours. Reduction in heaviness and tightness was also reported 24 hours after the exercise. JL

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Key Points

- It has been shown that physical activity is vital for breast cancer patients and that reduction of arm muscle strength is common, including those with arm lymphoedema.
- Weight-bearing exercises as well as other vigorous arm exercise can be performed without precipitating lymphoedema. However, at this point, careful follow-up of oedema volume should be made.
- The results of the volume measurements indicated a trend towards reduction of the arm lymphoedema the day after the heavy exercises had been performed, and the patients' own subjective assessments supported this trend.
- Prospective studies are needed to evaluate long-term effect of weight-bearing exercises on muscle strength and arm lymphoedema in breast cancer-treated women.

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