EXERCISE FOR LIMB LYMPHOEDEMA: EVIDENCE THAT IT IS BENEFICIAL

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Exercise has been shown to improve lymphatic propulsion, clearance and venous drainage from the limbs. However, awareness of the positive benefits of different exercise regimens for those with lymphoedema of the limb has been slow to emerge. Despite this, studies have demonstrated that various exercise regimens can have a positive impact on limb size, subjective limb symptoms and quality of life. This article will explore via a literature search, the evidence supporting the benefits of exercise for those with limb lymphoedema and propose how exercise may be incorporated into the patient's self-management programme.

Key words

Lymphoedema
Exercise
Limb size
Impact on symptoms

Following the debate in the first issue of the *Journal of Lymphoedema* on the impact of exercise and deep breathing on lymphoedema (Piller et al, 2006), it is timely to revisit the literature on these topics so that healthcare professionals may be better equipped to give the best advice to their patients. Having a broad understanding of the effect of exercise on the swollen limb will help clinicians to give appropriate advice to patients regarding the type, level and intensity of exercise that can be incorporated into the patient's self-management regimen. The role of exercise (which generally can be undertaken frequently by the patient at minimal cost and without taking much time off work) must also be considered when more expensive and labour intensive treatments cannot be accessed or are not affordable.

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Exercise and the lymphatic system

There is a good body of evidence which shows that exercise varies interstitial tissue pressure and influences both lymph propulsion and clearance, helping to transport fluid and inflammatory causing proteins (Havas et al, 1997; Olszewski and Engeset, 1998) from the site of formation and from the swollen limb or affected area. These effects were first studied in animals, with an increase in lymphatic contraction frequency and lymph flow being shown to occur in animals that exercised for both short and long durations (McGeown et al, 1987; Coates et al, 1993). The increase in lymphatic contraction and lymph flow that follows muscle activity can be explained by experiments undertaken by Mazzoni et al (1990) on the spino-trapezius muscle of rats. This research demonstrated that the stretched skeletal muscles pulled on the anchoring filaments joined to the initial lymphatics, helping fluid to move into the vessel. When the muscle was then contracted, the increase in the muscle fibre cross-section compressed the connective tissue and therefore the lymphatics, resulting in lymph being pushed towards the lymph collectors.

The positive effects of exercise on lymphatic function have also been demonstrated in human studies, with a study by Havas et al (2000) finding that two hours of steady exercise increased lymph clearance rate five-fold in the first 15 minutes, while the rest of the time it was increased 2–3-fold. These findings are also confirmed by a study by Lane et al (2005), which demonstrated increased lymphatic clearance in the hands of healthy women who performed arm crank ergonometry for five minutes.

The effect of exercise on the venous system is also of importance, especially in those with lower-limb swelling. The activation of the calf muscle pump via exercise has been shown to improve lower limb venous drainage in both healthy volunteers (Stick et al, 1993; Kugler et al, 2001) and those with chronic venous insufficiency (CVI) (Padberg et al, 2004). Specifically, the oedema reduction in CVI is achieved through the increase of venous ejection fraction and the subsequent decrease in residual venous fraction (Yang et al, 1999), which is brought about by the calf muscle contracting and relaxing. Lastly, the effects of deep breathing (which can be incorporated into exercise regimens) on the lymphatic and venous systems should not be overlooked. Studies have shown that the changes in intrathoracic pressure produced by deep breathing can increase lymphatic drainage through the thoracic lymphatic ducts (Shields, 1980) and positively influence venous return (Sumner, 1995).

Does exercise precipitate or worsen limb swelling?

Although the effects of exercise have long been known, the stand-alone benefits of exercise for the lymphoedematous limb have been slow to emerge. This may be traditionally related to clinicians and researchers being hesitant to recommend strenuous exercise in the fear that the increased blood flow to the limb muscles would exacerbate the swelling rather than help it. However, research has demonstrated that strenuous exercise can be undertaken by those at risk of developing lymphoedema and those who already have the condition without adverse effects. Two studies have shown that women who have undergone breast cancer treatment can participate in vigorous exercise — in this case boat racing (rowing) and upper body exercise — without exacerbating their lymphoedema, in those who have the condition, or increase the risk of developing it (Harris and Niesen-Vertommen, 2000; Lane et al, 2005). The ability to undertake more active exercise has also been demonstrated in other studies, including women with secondary arm lymphoedema undertaking resistive arm exercise with hand weights (McKenzie and Kalda, 2003; Johansson et al, 2004), a dance programme (Sandel et al, 2005) and a moderately intensive exercise programme which included aerobic and resistive exercise (Turner et al, 2004).

The effect of exercise on the lymphoedematous limb

To explore the benefits of exercise for secondary limb lymphoedema, a search of the literature was undertaken. This search focused upon exercise studies undertaken in the randomised controlled or cohort format and involving secondary limb lymphoedema populations (with no active cancer). Online databases were searched (limited to English) with the primary outcomes being a change in limb volume (measured via tape measure, perometry or water displacement methods) and subjective symptoms. The exercise regimes and their outcomes are summarised in *Tables 1* and *2*.

A variety of exercise regimens have been shown to be beneficial for people with secondary arm lymphoedema, both in terms of arm volume reduction and reported subjective improvement. This includes arm exercise combined with deep breathing (Moseley et al, 2005), resistive arm exercise with weights (McKenzie and Kalda, 2003; Johansson et al, 2004), a 30-minute limb exercise programme (Buckley et al, 2004) and hydrotherapy (Box et al, 2004; Johansson et al, 2004). Three of the studies that included control groups (McKenzie and Kalda, 2003; Box et al 2004; Moseley et al, 2005) demonstrated either a minimal decrease in limb volume or an actual increase when compared with the exercise group. The hydrotherapy study undertaken by Johansson et al (2004) provides important information on the optimal pool temperature to undertake exercise, with a temperature of 28°C producing an arm volume reduction but a temperature of 34°C resulting in a slight increase in volume.

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It is also worth noting that two studies (Buckley et al, 2004; Johansson et al, 2004) demonstrated an average initial increase in arm volume (12ml in both studies; p=n.s.), which presumably is related to an increased arterial flow to the arm muscles. More importantly, it was demonstrated that this was only a transient increase in volume, with an overall volume decrease being demonstrated after 20 minutes (24ml; p=n.s.) (Buckley et al, 2004) and 24 hours (15ml; p=n.s.) after exercise (Johansson et al, 2004). Although limb exercise is often undertaken by patients with lymphoedema while wearing a compression garment, only two studies (McKenzie and Kalda, 2003; Johansson et al, 2004) investigated this combination. Both studies involved resistive weight exercises while wearing a compression garment, with both demonstrating a reduction in arm volume of 15ml (at 24 hours) and 2% respectively. Interestingly, Johansson et al (2004) also investigated the same resistive weight exercises without using a compression garment, which also produced the same reduction (of 15ml) at 24 hours. However, in this session patients did report a significant ($p<0.001$) increase in physical exertion (which was not significant when undertaking the exercises while wearing the compression garment).

Only two studies (Moseley et al, 2003; Buckley et al, 2004) were found that fitted the search criteria and which investigated the effect of exercise on secondary leg lymphoedema. These studies demonstrated that both mechanical limb elevation plus passive exercise (Moseley et al, 2003) and 30 minutes of limb exercise (Buckley et al, 2004) can produce a reduction in limb volume and subjective improvements in symptoms. In the study by Moseley et al (2003), the limb volume reduction was quite significant (330ml; p=0.001), while in Buckley et al's (2004) study it was smaller (55ml; p=n.s.). Both studies also demonstrated a volume reduction at follow-up, including at 20 minutes post session (31ml; n=n.s.) (Buckley et al, 2004) and one month after the trial ended (220ml; p=0.032) (Moseley et al, 2003). Neither study included a control group so it is difficult to assess what would have occurred if no treatment was implemented.

The presented data indicates how a variety of exercise regimens, from aqua-therapy, resistive exercise, physical therapy, machine-based and Tai Chi can have a positive impact upon limb volume in people with limb lymphoedema. Moseley et al (2005) also demonstrated (through the use of multi-frequency bio-impedance measurement) that there is a reduction in trunk fluid directly after performing arm exercises combined with deep breathing. Follow-up measurements

Table 1

Summary of the evidence of the effect of different exercise regimens on arm lymphoedema

Regimen	n	Volume change	Subjective changes
Moseley et al (2005)			
Five cycles of 5 arm exercises involving muscle contraction and relaxation and deep breathing (10 minutes total)	38	After 10 minutes: 52ml (5.8%) reduction (p=0.004) 1-week follow-up: 33ml (3.3%) reduction (p=0.03)	Reduced heaviness and tightness (p<0.05) Reduced heaviness and limb size (p<0.05)
Exercise group: arm exercise involving muscle contraction and relaxation and deep breathing for 10 minutes morning and evening for one month	24	After 1 month: 101ml (9%) reduction (p=n.s.)	Reduced heaviness and limb size (p<0.05)
Control group: no active treatment. Measurements taken at the beginning and end of one month	28	Control group: 7ml (0.7%) reduction (p=n.s.)	No change
Box et al (2004)			
Exercise group: 45 minutes hydrotherapy; 15 minutes of slow rhythmical exercise; 20 minutes of whole body exercise; 10 minutes of warm-down exercise three times a week for four weeks	8	After four weeks: 48ml (4.8%) reduction Six-week follow-up: 86ml (8.6%) reduction (p=n.s.)	Reduced aching, heaviness, tightness (p=n.s.) Reduced swelling, stiffness and heat (p< 0.05)
Control group: no exercise intervention	8	After four weeks: 1.2ml (0.1%) increase Six-week follow-up: 32ml (3.2%) increase (p=n.s.)	Reduced aching, heaviness, and tightness (p=n.s.)
Johansson et al (2004)			
40 minutes hydrotherapy: 15 minutes of swimming followed by arm exercises with hand weights and a cooling-down period. Undertaken in two different pool temperatures — session 1: 28°C (82°F); session 2: 34°C (93°F). No control group	7	After first session: 32ml (12%) decrease (p=0.06) After second session: 2ml (0.7%) increase (p=n.s.)	No change No change
Johansson et al (2004)			
First session: resistive arm exercise with 0.5kg hand weight, plus wearing a compression garment	23	After first session12ml (0.5%) increase (p<0.05) 24-hour follow-up 15ml (0.7%) decrease (p=n.s.)	No change
Second session: resistive arm exercise with 0.5kg hand weight, minus wearing a compression garment		After second session: 10ml (0.3%) increase (p< 0.05) 24-hour follow-up: 15ml decrease (1.0%) (p=n.s.)	Increase in physical exertion (p<0.001)
Buckley et al (2004)			
Five minutes of instructed deep breathing plus self-massage followed by 30 minutes of isotonic and isometic limb exercises. No control group	7	After first session 12ml (0.4%) increase (p=n.s.) After 20 minutes: 24ml (0.8%) decrease (p=n.s.)	Reduced heaviness, movement limitation, skin dryness, tightness (p=n.s.)
McKenzie and Kalda, 2003			
Exercise group: resistive arm exercise plus wearing a compression garment, 3 x week for eight weeks	7	After eight weeks: 2% decrease (p=n.s.)	Improvement in general health, physical functioning, vitality (p<0.05)
Control group: wore compression garment only		Control group: 3% increase (p=n.s.)	Control: reduced general health, physical functioning, vitality (p=n.s.)

Table 2

Summary of the evidence of the effect of different exercise regimens on leg lymphoedema

Regimen	n	Volume change	Subjective changes
Moseley et al (2004)			
Machine delivered leg elevation and passive exercise to the limbs, 5–12 minutes, morning and evening for three weeks (no control group)	33	After three weeks: 330ml (33%) decrease (p=0.001) One-month follow-up 220ml (22%) decrease (p=0.032)	Reduced heaviness, limb size, skin dryness, tightness (p<0.05)
Buckley et al (2004)			
Five minutes of instructed deep breathing plus self-massage followed by 30 minutes of isotonic and isometic limb exercises (no control group)	7	After session: 55ml (5.8%) decrease (p=n.s.) After 20 minutes: 31ml (3.0%) decrease (p=n.s.)	Reduced heaviness, movement limitation, skin dryness, tightness (p=n.s.)

also show that there are often sustained reductions in limb volume, from 20 minutes (Buckley et al, 2004) to four and six weeks (Box et al, 2004; Moseley et al, 2003) post exercise regimen. Subjective symptoms also indicate that there are improvements in how the limb feels, looks and moves and in quality of life and general health parameters after performing exercise. It must be acknowledged that quite a few of these studies had small sample sizes (which may have also affected statistical significance) and did not include control groups, although the control data from two studies (McKenzie and Kalda, 2003; Box et al, 2004) does indicate that arm volume will increase if no form of treatment is undertaken. This has also been found in data collected by Casley-Smith (1997) who demonstrated that lymphoedema, when left untreated, will increase in amount and progress from lower to higher grades of classification.

Other benefits of exercise

The other positive benefits that can be derived from regular exercise should also not be ignored. In general, exercise can improve well being (Penedo and Dahn, 2005), cardiovascular fitness (Markes et al, 2006) and contribute to stress management (Taylor-Piliae et al, 2006). More importantly for those with limb swelling, exercise can improve limb flexibility plus range of movement (Brennan and Miller, 1998; Kahn et al, 2003) and facilitate weight maintenance. Weight management is particularly important for those at risk of, or who have limb swelling, as previous research has demonstrated that obesity can contribute to both lymphoedema development (Johansson et al, 2002) and the incidence of cellulitis (Herbertz, 1998).

Conclusion

It must be acknowledged that a few of the exercise regimens presented in *Table 1* only rendered a small limb volume reduction, which were at times not statistically significant. However, it can be concluded that exercise is of some benefit to those with this condition as it is likely to result in sustained limb volume reductions, changes in truncal fluid, subjective limb improvements and make a positive impact on quality of life and general health. A few of the studies also provide some important information when advising lymphoedema patients on exercise, including that the optimal temperature to undertake hydrotherapy is 28°C (Johansson et al, 2004) and that an arm volume reduction may be anticipated when resistive exercise is undertaken with or without wearing a compression garment (McKenzie and Kalda, 2003; Johansson et al, 2004). Current research also indicates that those at risk of, or with lymphoedema, can undertake strenuous exercise without adverse effects.

Obviously, when it comes to exercise, common sense on behalf of the clinician and the patient must be employed, and certainly going out and suddenly running a marathon or lifting extraordinarily heavy weights would not be recommended. Undertaking strenuous exercise must be appropriately worked up to, with the inclusion of a warm-up programme before exercise and especially a warming-down programme after exercise to help the lymphatic system to clear the excess fluid and metabolites which have leaked into the interstitial space. The studies by Box et al (2004) and Johansson et al (2004) indicate that the incorporation of a 10–15-minute warming-down programme at the end of active exercise may be adequate to render an overall limb reduction. Cooling the limb in cold water for 20 minutes immediately after exercise may also be of benefit, with research suggesting that this prevents oedema formation in the skeletal muscles (Yanagisawa et al, 2004). The incorporation of adequate rest periods in between exercise sessions and close monitoring of the limb's response (using objective measurements) should also form part of the overall management of those with limb lymphoedema who undertake regular exercise. JL

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Key points

- Exercise has been shown to improve lymph propulsion and clearance.
- Exercise has been shown to help reduce limb volume and improve subjective symptoms and quality of life.
- Benefits from exercise have been sustained post exercise regime in some studies.
- Exercise is a viable option for those with limb lymphoedema.