Exercise and secondary lymphoedema: safety, potential benefits and research-related issues.

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Abstract

Participating in regular physical activity is encouraged following breast cancer (BC) treatment, except for those who have subsequently developed lymphoedema. We designed a randomised controlled trial to investigate the effect of participating in a supervised, mixed-type, moderate-intensity exercise program among women with lymphoedema following breast cancer. Women <76 years who had completed BC treatment at least six months prior and subsequently developed unilateral, upper-limb lymphoedema were randomly allocated to an intervention (n=16) or control (n=16) group. The intervention group (IG) participated in 20 supervised group exercise sessions over 12 weeks, while the control group (CG) was instructed to continue habitual activities. Lymphoedema status was assessed by bioimpedance spectroscopy (impedance ratio between limbs) and perometry (volume difference between limbs). Mean baseline measures were similar for the IG (1.13±0.15 and 337±307ml, respectively) and CG (1.13±0.15 and 377±416ml, respectively) and no changes were observed over time. However, 2 women in the IG no longer had evidence of lymphoedema by study end. Average attendance was over 70% of supervised sessions, and there were no withdrawals. The results indicate that, at worst, exercise does not exacerbate secondary lymphoedema. Women with secondary lymphoedema should be encouraged to be physically active, optimising their physical and psychosocial recovery.

Keywords: Lymphoedema, breast cancer, physical activity

Introduction

By 18-months post-surgery, at least 30% of Australian breast cancer survivors have had lymphoedema (Hayes *et al*, 2008); a debilitating, distressing condition (Tobin *et al*, 1993), that impairs the performance of ordinary tasks (Carter, 1997; Mirolo *et al*, 1995), sets woman apart socially and is a constant reminder of the cancer (Petrek & Heelan, 1998). There is significant evidence demonstrating that participating in exercise during and following treatment for breast cancer is associated with improvements in psychosocial and physical outcomes (Courneya *et al*, 2002; Courneya, 2003; Friedenreich & Courneya, 1996; Hayes & Newman, 2006; Stevinson *et al*, 2004), and emerging evidence linking active lifestyles with improved survival (Abrahamson *et al*, 2006; Holick *et al*, 2008; Holmes *et al*, 2005). Women with lymphoedema have traditionally been excluded from participating in exercise for fear of exacerbating the condition. However, recent findings suggest that sedentary lifestyles may increase risk of developing lymphoedema (Hayes *et al*, 2008). Further, participating in regular exercise plays an important role in maintaining a healthy and stable body weight, and being overweight or obese are considered risk factors for developing lymphoedema (Edwards, 2000; Petrek, 2001).

While there is a paucity of research regarding the role of exercise for women with lymphoedema, preliminary work demonstrates that participation in an exercise programme does not precipitate lymphoedema, nor does it exacerbate the condition (Ahmed *et al*, 2006; Harris & Niesen-Vertommen, 2000; Lane *et al*, 2005; McKenzie & Kalda, 2003). Unfortunately, these studies are limited by the type of sample, lymphoedema measurement, duration of the exercise program and/or lack of long-term

follow-up. The purpose of this project was to investigate, in a randomised controlled trial (RCT), the effect of participating in a supervised, mixed-type, moderate-intensity exercise program on lymphoedema status, among women with lymphoedema following breast cancer and acceptability of the program.

Methods

Subject group

Women younger than 76 years, who had completed treatment for unilateral breast cancer at least six months prior, subsequently had unilateral, upper-limb lymphoedema diagnosed by a health professional, and were prepared to travel to the exercise clinic for 12 weeks (if randomly allocated to the intervention group) were eligible. Following ethical approval, study information packs (n=316) were distributed via lymphoedema-treating specialists (221), the Lymphoedema Association of Queensland (80) and our own database (31). Of those that responded (54% response rate), 27 women declined to participate and did not provide any patient or treatment information, 7 women were ineligible and 32 women were eligible and consented to participate. The remaining 106 women provided patient and treatment information but were unable to participate due to the intervention requirements.

Study design

This study was a single-blind, RCT of a specific exercise program. All measures were assessed pre-intervention (time 1; T1), immediately post-intervention (time 2; T2) and at 12-weeks follow-up (Time 3; T3), and were conducted by the same assessor who was blinded to participant group allocation. Participants were randomly allocated to the

intervention group (IG) or control group (CG) following T1. Stratifying according to severity of lymphoedema was necessary, since 38% of the sample (n=12) lacked objective evidence of the condition (CG, n=6; IG, n=6), as defined by our diagnostic criteria, at T1.

Intervention

The intervention involved a 12-week, moderate-intensity, mixed-type exercise program, including aerobic- and resistance-exercise (Table 1), conducted by an exercise physiologist and physiotherapist. Participants used the Borg's revised rating of perceived exertion scale(Borg, 1982) to monitor aerobic-based exercise intensity, while the maximum number of repetitions successfully completed with a given resistance assessed resistance-based intensity. Exercise progression occurred throughout the 12-week intervention period and the program was designed to maximise exposure to various types of exercise in an attempt to develop 'independent and capable exercisers' by study end. The prescriptive nature of the program progressed to levels that meet national physical activity guidelines(Australian Institute of Health and Welfare, 2004), and on completion of the intervention, participants were instructed to continue with their established exercise regime but were not monitored.

Measures

Lymphoedema was assessed via standard objective measures, specifically bioimpedance spectroscopy (BIS; SEAC SFB3, Impedimed, Brisbane, Australia) and perometery (Manual Perometer Type 350 S, Pero-System Messgeraete GMBH, Wuppertal, Germany). Using BIS, the impedance of the extracellular fluid for each limb at a range

of frequencies was assessed using the manufacturer's software, and the ratio of these values comparing the treated and untreated sides was calculated. Lymphoedema was considered to be present when the impedance ratio was more than three standard deviations above normative data, taking into account the significant effect of limb dominance(Cornish *et al*, 2001). Perometry involved inserting the upper-limb into a horizontally-oriented frame that emits two parallel arrays of infra-red light beams at right angles to each other. By assuming an elliptical cross-section, volume of both limbs and the volume difference between the limbs were calculated. Lymphoedema was deemed present when the volume of the treated side was at least 200ml more than the untreated side.

We also recorded number of supervised sessions attended per participant as well as reasons given for periods of absence. Qualitative comments regarding the program and lymphoedema status, provided by the women during exercise sessions were recorded. For both IG and CG, data were collected via self-report on patient and treatment characteristics (Table 2). At T2 and T3, additional information on changes made to undergarments, compression garments and/or lymphoedema treatment was collected. Women also responded to prompts, such as 'you may wish to tell us what having lymphoedema feels like, what do you think caused your lymphoedema, whether certain activities aggravate or improve your lymphoedema' in the questionnaire**.**

Statistical analysis

Lymphoedema values as assessed by BIS (ratios) and perometry (volumes in ml) were approximately normal for the study group at each testing phase, as were change scores

between T1 and T2, and T1 and T3. Therefore, means and standard deviations have been used with independent t-tests (two-tailed $P<0.05$) to determine statistical significance of observed changes. Qualitative comments were examined to determine the presence of common themes or points of difference across respondents and phases.

Results

Group characteristics

The patient and treatment characteristics of the study sample (n=32) were similar to those who were unable to participate (n=106), although the participants were more likely to have been diagnosed with breast cancer more than 5 years previously (Table 2). The IG and CG also reported comparable patient and treatment characteristics at baseline, with mean age approximately 60 years, about half reporting low levels of education and more than two-thirds being in a significant relationship, with children. Breast cancer was diagnosed more than 5 years ago for 70% of IG and CG, while about half of the CG but only one-third of the IG experienced lymphoedema for more than 5 years. Lymphoedema-treatment characteristics of the groups were similar, and comparable behaviours at baseline were also observed (data not shown).

Lymphoedema

There were no significant differences in lymphoedema status at baseline or changes between testing phases observed between the IG and CG. Mean impedance ratios at T1 were 1.13 ± 0.15 for the IG and 1.13 ± 0.15 for the CG, while mean changes in impedance ratios between T1 and T2 were -0.01 ± 0.06 and -0.00 ± 0.09, and between T1 and T3 were 0.02 ± 0.07 and 0.01 ± 0.09 for the IG and CG, respectively (Table 3). With

perometry, baseline volume difference for the IG and CG were 337±307ml and 377±416ml, respectively. Mean volume changes between testing phases were insignificant and ranged from 2ml (IG: T1-T3) to 43ml (CG: T1-T2) (Table 3).

Bioimpedance spectroscopy

Evaluation of individual lymphoedema status by BIS at each of the three testing phases demonstrated that 9 of 16 (56%) IG participants had measurable evidence of the condition at T1. Two (13%) of these women showed clinical improvements, so that by T3, they no longer had measurable lymphoedema. One IG participant experienced a significant increase in swelling throughout the study period (ratios/volumes = T1: 1.16/689ml; T2: 1.47/923ml; T3: 2.25/1870ml). This participant attended 50% of the group-supervised sessions (sessions 1-8, 10, 20), all at low to moderate intensity involving whole-body, aerobic-based exercise. A prolonged or repeated upper respiratory tract infection was the reason for missed sessions, and her lymphoedema became worse midway through her illness period. Since completion of the study, this participant continued to experience worsening lymphoedema that did not respond to treatment and was later diagnosed with recurrent disease (approximately 6 months after study end). Due to these circumstances, her data were removed. Importantly, no adverse changes to lymphoedema status were found in those who participated more completely and at higher intensities in the intervention. In regards to the CG, 6 women (38%) had measurable evidence of the condition at T1 and T3; an additional woman had measurable evidence of lymphoedema at T2, however her ratio declined again to within 'normal' by T3. One of the 16 women (6%) in the CG showed a clinical decline in her

ratio over time, but continued to have measurable evidence of the condition by T3. The remainder of the CG had relatively stable ratios over time.

Perometry

With perometry, 9 out of 15 (60%) and 8 out of 14 (57%) IG women had measurable evidence of lymphoedema at T1 and T3, respectively, while 9 out of 16 (56%) and 10 out of 15 (67%) CG women had evidence of lymphoedema at T1 and T3, respectively. Fluctuations of more than 10% volume difference between the treated and untreated sides were observed for individuals in both groups, irrespective of lymphoedema status according to perometry criteria, and resulted in overall group declines of 6% in the IG and 5% in the CG.

Study adherence

The majority of women (88%) allocated to the IG participated in 70% or more of scheduled supervised exercise sessions. The intervention was scheduled over winter, and missed sessions were mostly related to respiratory illnesses (n=10). Other reasons included were having a skin lesion removed (n=1), having gynaecological-surgery (n=1) and work commitments (n=2). As already noted, one participant missed 50% of supervised sessions. All participants (n=32) participated in T1 and T2, while data were unavailable for 2 participants (one in the IG and one in the CG) at T3. To ensure missing data did not contribute to results found, data analysis was repeated excluding these 2 participants and no differences in results were observed (data not shown).

Qualitative data

Comments recorded on the self-reported questionnaire revealed one overarching concern: **lymphoedema impacts all facets of an individual's life.** Illustrative quotes are provided in Table 4. The sense of grief and frustration expressed by many women was exacerbated by uncertainty about the likely outcome of lymphoedema treatment, conflicting advice from health professionals, and the perceived need to maintain vigilance about activities that might exacerbate the problem, despite lack of clear evidence to guide them. In addition, more in-depth interactions with those in the IG provided us with insight into how their feelings about being active evolved, including their sense of greater well-being and the importance of the program being 'supervised'. However, despite providing positive comments regarding exercise participation and lymphoedema, women in both groups also suggested that "in particular heavy or repetitive use" or "heavy lifting" "aggravates the arm". Finally, among the IG, the fear that exercise may adversely effect their lymphoedema and that change in arm symptoms are related to worsening lymphoedema status were also evident. One-third of the IG (6 women) became concerned during the intervention because their arm symptoms were changing and thought this was indicative of their lymphoedema progressing. As a consequence, we conducted a re-assessment by BIS around week 6. At that time, 5 of the 6 women showed clinical improvements, while the other woman showed no change. The results gave the women reassurance and confidence that their arms were not adversely changing.

Discussion

Use of the treated arm following breast cancer treatment and the potential to influence risk of developing lymphoedema is a topic with limited evidence driving clinical

recommendations. While it seems sensible to be cautious regarding use of the treated side, it is pertinent to acknowledge that the 'muscle pump' is considered the primary mechanism for moving lymph throughout the body(Tortora, 1992), and participating in physical activity activates the muscle pump mechanism. This single-blind, RCT sought to evaluate the effect of participating in a 12-week supervised-exercise program on lymphoedema status among women previously diagnosed with clinical lymphoedema following breast cancer.

No group changes were observed in lymphoedema status over the study period, although two of nine IG women (22%) with clinical evidence (by BIS) at baseline no longer had evidence of the condition at T3. These results support the notion that participation in exercise is safe for those with upper-limb lymphoedema, and that at worst, exercise does not exacerbate swelling. The specific intervention involved both aerobic- and resistance-based exercise, that targeted large as well as small muscle groups, including those of the upper-limb, and was undertaken at moderate to high intensities. No adverse changes on lymphoedema status have been reported by others who have also examined the effect of mixed-type exercise programs (aerobic- and resistance-based)(McKenzie & Kalda, 2003; Turner *et al*, 2004) or resistance-based exercise alone(Ahmed *et al*, 2006), set at moderate intensities. These are important findings, since it is known that sedentary lifestyles are associated with being overweight and that both of these characteristics are independent risk factors for developing breast cancer(Cleveland, 2007; Friedenreich, 2001; Thune & Furberg, 2001), lymphoedema following breast cancer(Edwards, 2000; Hayes *et al*, 2005; Hayes *et al*, 2008; Petrek, 2001), and reduced survival following breast cancer(Abrahamson *et al*, 2006; Holick *et*

al, 2008; Holmes *et al*, 2005). Therefore, while exercise currently lacks an evidence base in support of managing lymphoedema, its indirect role in maintaining healthy lifestyles and body weight following breast cancer as well as minimising risk of recurrence and optimising survival should be not be overlooked.

As noted earlier, lymphoedema for one participant in the intervention group adversely progressed. However, this seemed unrelated to group allocation as her participation in the program was limited, and when she did participate, the program was at low-intensity and constituted whole-body exercise. Throughout and beyond the study period, the participant was under medical review and was subsequently diagnosed with recurrence. Whether her progression of lymphoedema was coincidental with progression of disease or provided an early sign is unknown but potentially worthy of future consideration.

The profound effects that lymphoedema may have on a woman life's have been previously described(Thomas-MacLean *et al*, 2005). Gross and fine motor skills can be affected(Rymal, 2001), impacting work, home and personal care functions, as well as recreational activities and social relationships(Passik & McDonald, 1998). Other physical symptoms may include feelings of discomfort, heaviness, pain, tenderness and aching, and reports of multiple associated symptoms are common(Moffatt *et al*, 2003). In addition to physical symptoms, psychological distress, depression and anxiety(Carter, 1997) as well as changes in body image and self-image have been reported, with dressing concerns reflecting one practical issue (Woods, 1993). The women in this study have further confirmed that lymphoedema does not just affect the treated side or limb; it influences the whole body and it "affects some capacity of every day-to-day

activity". Further, having lymphoedema brings with it a degree of social isolation, as it is an "unknown condition to many" including health professionals, friends, family and acquaintances. It is a condition that is "difficult to explain" but "visible to all". Accepting and surviving a breast cancer diagnosis is one thing, but coming to terms with the pervasive impact and uncertain course of lymphoedema is another.

While the fear associated with the risk of developing lymphoedema has been previously reported(Petrek & Heelan, 1998), the women in this study emphasised that those with lymphoedema continue to live with fear - fear that their lymphoedema may progress. Women with breast cancer receive mixed messages from health professionals and various resources about optimal use of their treated arm. These inevitably contribute to the trepidation women have regarding participation in particular activities. Further, the IG participants highlighted just how acutely aware women with lymphoedema are of how their lymphoedematous side feels and how capable they are of identifying changes in arm symptoms. Changing arm symptoms led to unplanned assessment of lymphoedema status midway through the intervention for 6 participants. When the women were asked to describe the changes as being 'good', 'bad' or 'just different', the consensus was 'just different'; but the results demonstrated improved objective status. It seems plausible that the increase in physical activity levels were contributing to changes in lymph movement and/or load, and in turn, changes in arm symptoms. It was clear that had these women not been under supervision and assessment, these changes in arm symptoms would have led to withdrawal from their planned exercise. Other qualitative comments provided by the IG participants further highlighted the importance of the intervention being supervised.

Anecdotally, current practice encourages use of garments while exercising. As this recommendation lacks an evidence base, we encouraged each IG participant to make this decision herself. Three women (22%) chose to wear a garment while exercising. Similar to findings from others(Johansson *et al*, 2005), no relationship between garment use and change in lymphoedema status was identified. While these results are preliminary and require replication, factors such as impairment of heat transfer mechanisms, reduced range of motion and discomfort associated with wearing garments should be considered by clinicians and patients when making decisions about garment use during exercise.

The intervention was designed by a team experienced in both research and clinical practice and reflecting the disciplines of exercise physiology, physiotherapy and psychiatry. The primary outcome, lymphoedema, was assessed using two objective measures, and data collection allowed for 3-month follow-up to determine potential longer-term effects. Despite extensive recruitment strategies, only 32 eligible women participated in the study. While the participants had similar personal, treatment and behavioral characteristics compared with those who were unable to participate (n=106), it is likely that an overall response bias exists. Those who responded to our recruitment efforts were likely a more active (less than 10% of the entire study sample were sedentary at T1), educated and affluent group, with the time and/or resources to seek more effective mechanisms to treat and manage their lymphoedema. Also, 38% of the sample lacked measurable evidence of lymphoedema at baseline. It is therefore plausible that the intervention effect (positive or negative) on lymphoedema status

would be more difficult to observe. Nonetheless, this was a RCT, with the IG and CG participants similar in personal, treatment and behavioural characteristics at baseline, using a single researcher for assessment, blinded to participant group allocation. As such, the results of this work contribute to the growing body of evidence that those with lymphoedema can safely participate in exercise and that precluding participation in exercise for this subgroup of breast cancer survivors removes a plausible mechanism by which significant improvements in quality and quantity of survival could be attained.

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References

Abrahamson PE, Gammon MD, Lund MJ, Britton JA, Marshall SW, Flagg EW, Porter PL, Brinton LA, Eley JW, Coates RJ (2006) Recreational physical activity and survival among young women with breast cancer. *Cancer* **107:** 1777-1785

Ahmed RL, Thomas W, Yee D, Schmitz KH (2006) Randomized controlled trial of weight training and lymphedema in breast cancer survivors. *Journal Of Clinical Oncology: Official Journal Of The American Society Of Clinical Oncology* **24:** 2765-2772

Australian Institute of Health and Welfare (ed) (2004) Australia's health 2004. AIHW: Canberra

Borg GAV (1982) Psychological bases of physical exertion. *Med Sci Sport Exer* **14:** 377-381

Carter BJ (1997) Women's experiences of lymphoedema. *Oncol Nurs Forum* **24:** 875-882

Cleveland RJ (2007) Weight gain prior to diagnosis and survival from breast cancer. *Cancer Epidemiology, Biomarkers & Prevention: A Publication Of The American Association For Cancer Research* **16:** 1803-11

Cornish B, Chapman M, Hirst C, Mirolo B, Bunce I, Ward L, Thomas B (2001) Early diagnosis of lymphedema using multiple frequency bioimpedance. *Lymphology* **34:** 2-11

Courneya K, Mackey JR, McKenzie DC (2002) Exercise after breast cancer: research evidence and clinical guidelines. *Physician Sportsmed* **30:** 33-42

Courneya KS (2003) Exercise in cancer survivors: An overview of research. *Med Sci Sport Exer* **35:** 1846-1852

Edwards TL (2000) Prevalence and aetiology of lymphoedema after breast cancer treatment in southern Tasmania. *Aust NZ J Surg* **70:** 412-418

Friedenreich C (2001) Review of anthropometric factors and breast cancer risk. *European Journal of Cancer Prevention* **10:** 15-32

Friedenreich CM, Courneya KS (1996) Exercise as rehabilitation for cancer patients. *Clin J Sport Med* **6:** 237-244

Harris SR, Niesen-Vertommen SL (2000) Challenging the myth of exercise-induced lymphodema following breast cancer: A series of case reports. *J Surg Oncol* **74:** 95-99

Hayes S, Cornish B, Newman B (2005) Comparison of methods to diagnose lymphoedema among breast cancer survivors: 6-month follow-up. *Breast Cancer Res Tr* **89:** 221-226

Hayes S, Newman B (2006) Exercise in Cancer Recovery: An overview of the evidence. *Cancer Forum* **30:** 13-17

Hayes SC, Janda M, Cornish B, Battistutta D, Newman B (2008) Lymphoedema following breast cancer: incidence, risk factors and effect on upper body function. *J Clin Oncol* **26:** DOI: 10.1200/JCO.2007.14.4899

Holick CN, Newcomb PA, Trentham-Dietz A, Titus-Ernstoff L, Bersch AJ, Stampfer MJ, Baron JA, Egan KM, Willett WC (2008) Physical activity and survival after diagnosis of invasive breast cancer. *Cancer Epiderm Biomar* **17:** 379-386

Holmes M, Chen W, Feskanich D, Kroenke C, Colditz G (2005) Physical activity and survival after breast cancer diagnosis. *JAMA: Journal of the American Medical Association* **293:** 2479-2486

Johansson K, Tibe K, Weibull A, Newton RC (2005) Low intensity resistance exercise for breast cancer patients with arm lymphedema with or without compression sleeve. *Lymphology* **38:** 167-180

Lane K, Jespersen D, McKenzie DC (2005) The effect of a whole body exercise programme and dragon boat training on arm volume and arm circumference in women treated for breast cancer. *Eur J Cancer Care* **14:** 353-358

McKenzie DC, Kalda AL (2003) Effect of upper extremity exercise on secondary lymphedema in breast cancer patients: a pilot study. *J Clin Oncol* **21:** 463-466

Mirolo BR, Bunce IH, Chapman M, Olsen T, Eliadis P, Hennessy JM, Ward LC, Jones LC (1995) Psychosocial benefits of post-mastectomy lymphoedema therapy. *Cancer Nurs* **18:** 197-205

Moffatt CJ, Franks PJ, Doherty DC, Williams AF, Badger C, Jeffs E, Bosanquet N, Mortimer PS (2003) Lymphodema: An underestimated health problem. *Q J Med* **96:** 731-738

Passik SD, McDonald MV (1998) Psychosocial aspects of upper extremity lymphedema in women treated for breast carcinoma. *Cancer* **83:** 2817-2820

Petrek JA (2001) Lymphedema in a cohort of breast carcinoma survivors 20 years after diagnosis. *Cancer* **92:** 1368-1377

Petrek JA, Heelan MC (1998) Incidence of breast carcinoma-related lymphedema. *Cancer* **83:** 2776-2781

Rymal C (2001) Lymphedema management in patients with lymphoma. *Nursing Clinics of North America* **36:** 709-734

Stevinson C, Lawlor DA, Fox KR (2004) Exercise interventions for cancer patients: Systematic review of controlled trials. *Cancer Cause Control* **15:** 1035-1056

Thomas-MacLean R, Miedema B, Tatemichi SR (2005) Breast cancer-related lymphedema: women's experiences with an underestimated condition. *Can Fam Physician* **51:** 246-247

Thune I, Furberg A (2001) Physical activity and cancer risk: dose-response and cancer, all sites and site-specific. *Med Sci Sport Exer* **33:** S530-S550

Tobin MB, Lacey HJ, Meyer L, Mortimer PS (1993) The psychological morbidity of breast cancer related arm swelling: Psychological morbidity of lymphoedema. *Cancer* **72:** 3248-3252

Tortora GJ (1992) *Principles of Human Anatomy, sixth edition*edn. New York, New York: Harper Collins

Turner J, Hayes SC, Reul-Hirche H (2004) Improving the physical status and quality of life of women treated for breast cancer: a pilot study of a structured exercise intervention. *J Surg Oncol* **86:** 141-146

Woods M (1993) Patients' perceptions of breast cancer related lymphoedema. *Eur J Cancer* **2:** 125-128

Table 1 Parameters of the exercise intervention

Type:	
Weeks 1-2	Aerobic only (floor-based aerobic exercise to music and walking)
Weeks 3-4	Aerobic (floor-based aerobic exercise to music, water-based aerobic exercise and walking) and water-based resistance exercises
Weeks 5-8	Aerobic (mix of all types) and water-based and free-weight resistance exercises
Weeks 9-12	Aerobic (mix of all types) and machine-weight resistance exercise
Intensity:	
Weeks 1-4	Aerobic: low to moderate (RPE[a]: 3-5) Resistance: low (≈20 repetitions per exercise)
Weeks 5-8	Aerobic: Moderate (RPE[a]: 4-6) Resistance: Moderate (last successfully completed repetition reached at approximately 15 repetitions per exercise)
Weeks 9-12	Aerobic: Moderate to high (RPE[a]: 4-7) Resistance: Moderate to high (last successfully completed repetition reached at approximately 10 repetitions per exercise)
Duration:	
Weeks 1-4	20-30 minutes/session
Weeks 5-8	30-45 minutes/session
Weeks 9-12	45+ minutes/session
Frequency:	
Weeks 1-4	3 times per week (2 supervised[b])
Weeks 5-8	4 times per week (2 supervised[b])

Weeks 9-12	At least 4 times per week (1 supervised[b])

All sessions included upper and lower body stretches as part of the warm-up and cool-down periods

[a] Rating of Perceived Exertion Scale; [b] Supervised sessions were group-based with a maximum of 10 women in any session

Table 2 Personal, demographic and clinical characteristics of non-participants and participants

Personal and treatment-related characteristics	Non-participants		Participants		Participants			
					Control		Intervention	
	n		n		n		n	
Age (years) (mean±SD)	106	(60±10)	32	(59±9)	16	(60±11)	16	(59±7)
	n	(%)	n	(%)	n	(%)	n	(%)
Children in care								
Never	19	(18)	5	(16)	2	(12)	3	(19)
Children (unknown ages)	28	(26)	10	(31)	5	(31)	5	(3)
Children aged >14 years	51	(48)	14	(44)	8	(50)	6	(38)
Children aged ≤ 14 years	8	(8)	3	(9)	1	(6)	2	(13)
Education[a]								
Low	57	(54)	16	(50)	7	(44)	9	(56)
Moderate	33	(31)	9	(28)	5	(31)	4	(25)
High	16	(15)	7	(22)	4	(25)	3	(19)
Marital status								
Married/de facto	71	(67)	23	(72)	12	(75)	11	(69)
Single/widowed/divorced	35	(33)	9	(28)	4	(25)	5	(31)
Treated side								
Dominant	53	(50)	19	(59)	8	(50)	11	(69)
Non-dominant	53	(50)	13	(41)	8	(50)	5	(31)

Personal and treatment-related characteristics	Non-participants	Participants	Participants	
			Control	Intervention
Years since breast cancer treatment				
6 months – 5 years	57 (54)	10 (31)	5 (31)	5 (31)
>5 years	49 (46)	22 (69)	11 (69)	11 (69)
Adjuvant treatment (yes)				
Chemotherapy	41 (39)	17 (53)	7 (44)	10 (63)
Radiotherapy	79 (75)	21 (66)	11 (69)	10 (63)
Hormone Therapy	51 (48)	14 (44)	8 (50)	6 (38)
Extent of lymph node removal				
All	30 (28)	10 (31)	6 (38)	4 (25)
1+	76 (72)	22 (69)	10 (63)	12 (75)
Years since lymphoedema diagnosis				
<1 year	18 (17)	3 (9)	2 (13)	1 (7)
1-5 years	47 (44)	15 (47)	6 (38)	9 (64)
>5 years	23 (24)	12 (38)	8 (50)	4 (29)
Current lymphoedema treatment				
Physiotherapy	13 (12)	4 (13)	2 (13)	2 (13)
Massage	44 (42)	13 (41)	5 (31)	8 (50)
Compression	27 (26)	9 (28)	4 (25)	5 (31)
Exercise	8 (8)	0 (0)	0 (0)	0 (0)
Lymphatic drainage	6 (6)	1 (3)	0 (0)	1 (7)
laser	6 (6)	3 (9)	3 (19)	0 (0)

Personal and treatment-related characteristics	Non-participants	Participants	Participants	
			Control	Intervention
Other	4 (4)	1 (4)	1 (6)	0 (0)

* p values not shown but all were greater than 0.10; [a] Education categories: Low education defined as no formal education through to Grade 10 high school, Moderate education defined as completing school (Grade 12) or a trade/apprenticeship, High education defined as any formal education beyond completing Grade 12 high school.

Table 3 Changes observed in lymphoedema between pre- and post- intervention and pre-intervention and 3-months follow-up

		Change between T1[a] and T2[b]		Change between T1[a] and T3[c]		
Measures of lymphoedema	N	Mean	(SD)	Mean	(SD)	P values
Bioimpedance spectroscopy (ratio)						
Control Group	16	-.00	(.09)	.01	(.09)	0.75
Intervention Group	15	-.01	(.06)	.02	(.07)	0.88
Perometry (volumes, ml)						
Control Group	16	43	(97)	19	(73)	0.35
Intervention Group	15	13	(81)	2	(71)	0.53

[a] T1, pre-intervention; [b] T2, post-intervention; [c] T3, three-month follow-up

Table 4 Prominent themes emerging from participant written or verbal comments (both intervention and control groups)

Themes	Illustrative quotes
Pervasive impact of lymphoedema	"..it [lymphoedema] affects some capacity of every day-to-day activity." "Feel like my whole body is affected by this lymphoedema." "I don't like the way my arm seems to affect all extremities especially my left arm and my back." "It just seems all the energy is gone at times and you really have to force yourself to do things."
Grief, loss and uncertainty	"I have tried many things to help myself and try to control the swelling, the pain I am experiencing but nothing seems to help, or if it does, it's only briefly. I only want relief from this swelling……At present I cannot come to terms with what has happened to my arm, because there are many things and reasons I hate about it."
Isolation/Social impact	"..only talk to persons who may have had it [lymphoedema] – as it is difficult trying to explain." "the need to wear a constrictive sleeve always prompts questions from people which I find difficult to answer." "compression garment hard to hide so tend not to wear same."
Evolving feelings regarding exercise, including their sense	"It [exercise] makes me feel like I am able to use it more." "Sweeping seems to be a good exercise! Lifting grandchildren also a good exercise (not so good on the back!). Inactivity can

of greater well-being	exacerbate the lymphoedema." "I felt the lymphoedema was more under control while I was participating in the supervised exercise sessions (I also felt fitter at the latter part of the 12 weeks)." "I never knew I was able to do so much." HOWEVER, when asked what 'aggravates your lymphoedema' heavy or repetitive use and heavy lifting featured in responses (2 in the IG, 2 in the CG).
Importance of the program being 'supervised'	"Without having you to guide me, there is no way I would have ever done the things I've done as part of this program." "You gave me the confidence to know what I and my arm can do." "I would not have tried the things I've done if not for the study. I now feel capable of joining an aqua class." "You've shown me what I can do rather then tell me what I shouldn't do."