Exercise and Secondary Lymphedema: Safety, Potential Benefits, and Research Issues

SANDI C. HAYES[1], HILDEGARD REUL-HIRCHE[2], and JANE TURNER[3]

[1]School of Public Health, Institute of Health and Biomedical Innovation, Queensland University of Technology, Brisbane, Queensland, AUSTRALIA; [2]Department of Physiotherapy, Royal Brisbane and Women's Hospital, Queensland, AUSTRALIA; and [3]School of Psychiatry, Royal Brisbane and Women's Hospital, University of Queensland, Queensland, AUSTRALIA

ABSTRACT

HAYES, S. C., H. REUL-HIRCHE, and J. TURNER. Exercise and Secondary Lymphedema: Safety, Potential Benefits, and Research Issues. *Med. Sci. Sports Exerc.*, Vol. 41, No. 3, pp. 483–489, 2009. **Purpose**: Participating in regular physical activity is encouraged after treatment for breast cancer, with exception of those who have subsequently developed lymphedema. The purpose of this project was to investigate, in a randomized controlled trial, the effect of participating in a supervised, mixed-type exercise program on lymphedema status among women with lymphedema after breast cancer. **Methods**: Women younger than 76 yr, who completed breast cancer treatment at least 6 months prior and had subsequently developed unilateral, upper-limb lymphedema, were randomly allocated to an intervention (n = 16) or control (n = 16) group. The intervention group (IG) participated in 20 supervised, group, aerobic and resistance exercise sessions over 12 wk, whereas the control group (CG) was instructed to continue habitual activities. Lymphedema status was assessed by bioimpedance spectroscopy (impedance ratio between limbs) and perometry (volume difference between limbs), and independent t-tests (two-tailed $P < 0.05$) were used to determine statistical significance of observed changes. **Results**: Mean ratio and volume measures at baseline were similar for the IG (1.13 ± 0.15 and 337 ± 307 mL, respectively) and the CG (1.13 ± 0.19 and 377 ± 416 mL, respectively), and no changes were observed over time for either group. Although no group change was observed between preintervention and 3-month follow-up for the IG (ratio and volume change = 0.02 ± 0.07 and 2 ± 71 mL, respectively), two women in this group no longer had evidence of lymphedema by study end. Average attendance was more than 70% of supervised sessions, there were no withdrawals, and several qualitative comments from participants support the program acceptability. **Conclusions**: The results from this pilot study indicate that, at minimum, exercise does not exacerbate secondary lymphedema. Women with secondary lymphedema should be encouraged to be physically active, optimizing their physical and psychosocial recovery. **Key Words:** PHYSICAL ACTIVITY, BREAST CANCER, RECOVERY, TREATMENT-RELATED SIDE EFFECTS, ARM SWELLING

By 18 months postsurgery, at least 30% of Australian breast cancer survivors have had lymphedema (16), a debilitating, distressing condition (31) that impairs the performance of ordinary tasks (5,22), sets woman apart socially, and is a constant reminder of the cancer (26). There is significant evidence demonstrating that participating in exercise during and after treatment for breast cancer is associated with improvements in psychosocial and physical outcomes (8,9,12,15,28) and emerging evidence linking active lifestyles with improved survival (1,17,18). Women with lymphedema 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 lymphedema (16). Further, participating in regular exercise plays an important role in maintaining a healthy and stable body weight, and being overweight or obese is considered risk factors for developing lymphedema (10,25).

Although there is a paucity of research regarding the role of exercise for women with lymphedema, preliminary work demonstrates that participation in an exercise program does not precipitate lymphedema nor does it exacerbate the condition (2,13,20,21). Unfortunately, these studies are limited by the type of sample (include no or only some women with lymphedema), size of the sample (n = 14–45), methods of lymphedema assessment (indirect methods

Address for correspondence: Sandi C. Hayes, M.D., School of Public Health, Institute of Health and Biomedical Innovation, Queensland University of Technology, Victoria Park Rd, Kelvin Grove, Brisbane, QLD 4059, Australia; E-mail: sc.hayes@qut.edu.au.
Submitted for publication June 2008.
Accepted for publication August 2008.

0195-9131/09/4103-0483/0
MEDICINE & SCIENCE IN SPORTS & EXERCISE®

DOI: 10.1249/MSS.0b013c31818b98fb

used), duration of the exercise program, and/or lack of long-term follow-up. The purpose of this project was to investigate, in a randomized controlled trial (RCT) using a direct objective method of lymphedema assessment, the immediate- and longer-term effect of participating in a supervised, mixed-type exercise program on lymphedema status among women with lymphedema after breast cancer. The study also sought to determine the acceptability of the program from the participant's perspective.

METHODS

Subject group. Women younger than 76 yr, who had completed treatment for unilateral breast cancer at least 6 months prior, subsequently had unilateral, upper-limb lymphedema diagnosed by a health professional, and were prepared to travel to the exercise clinic for 12 wk (if randomly allocated to the intervention group [IG]) were eligible. There were no other exclusion criteria applied. After ethical approval, study information packs (n = 316) were distributed via lymphedema-treating specialists (221), the Lymphedema 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 provided informed written consent 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 preintervention (time 1; T1), immediately postintervention (time 2; T2), and at 12-wk follow-up (time 3; T3) and were conducted by the same assessor who was blinded to participant group allocation. Participants were randomly allocated (using a computer generated table of random numbers) to the intervention group (IG) or the control group (CG) after T1. Stratifying according to severity of lymphedema was necessary because 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-wk, mixed-type exercise program, including aerobic and resistance exercise (Table 1), conducted by an exercise physiologist and physiotherapist. Although intensity was most often "moderate," intensity progressed throughout the program. Participants used the Borg's revised rating of perceived exertion scale (4) 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-wk intervention period, and the program was designed to maximize 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 (3),

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: 3–5) Resistance: low (≈20 repetitions per exercise)
Weeks 5–8	Aerobic: moderate (RPE: 4–6) Resistance: moderate (last successfully completed repetition reached at approximately 15 repetitions per exercise)
Weeks 9–12	Aerobic: moderate to high (RPE: 4–7) Resistance: moderate to high (last successfully completed repetition reached at approximately 10 repetitions per exercise)
Duration	
Weeks 1–4	20–30 min per session
Weeks 5–8	30–45 min per session
Weeks 9–12	45+ min per session
Frequency	
Weeks 1–4	3 times per week (2 supervised[a])
Weeks 5–8	4 times per week (2 supervised[a])
Weeks 9–12	At least 4 times per week (1 supervised[a])

All sessions included upper and lower body stretches as part of the warm-up and cool-down periods.
[a] Supervised sessions were group based, with a maximum of 10 women in any session.
RPE, rating of perceived exertion scale.

and on completion of the 12-wk intervention, participants were instructed to continue with their established exercise regime but were not monitored. The decision to wear compression garments during exercise sessions or not was left up to each participant.

Measures. Lymphedema was assessed via standard objective measures, specifically bioimpedance spectroscopy (BIS; SEAC SFB3; Impedimed, Brisbane, Australia) and perometry (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. Lymphedema was considered to be present when the impedance ratio was more than three SD above normative data, taking into account the significant effect of limb dominance (7). Perometry involved inserting the upper limb into a horizontally oriented frame that emits two parallel arrays of infrared light beams at right angles to each other. By assuming an elliptical cross-section, the volume of both limbs and the volume difference between the limbs were calculated. Lymphedema was deemed present when the volume of the treated side was at least 200 mL more than the untreated side. For the purpose of power calculations, a 10% change in perometry volumes and a 0.2 change in BIS ratio were considered clinically relevant. Approximately 10 women per group were required to detect this level of change or difference between groups, with power and significance set at 80% and 5%, respectively.

TABLE 2. Personal, demographic, and clinical characteristics of nonparticipants and participants.

Characteristics	Nonparticipants	Participants All	Participants Control	Participants Intervention
Age (yr), *n* (mean ± SD)	106 (60 ± 10)	32 (59 ± 9)	16 (60 ± 11)	16 (59 ± 7)
Children in care, *n* (%)[a]				
Never	19 (18)	5 (16)	2 (12)	3 (19)
Children (unknown ages)	28 (26)	10 (31)	5 (31)	5 (3)
Children aged >14 yr	51 (48)	14 (44)	8 (50)	6 (38)
Children aged ≤14 yr	8 (8)	3 (9)	1 (6)	2 (13)
Education, *n* (%)[b]				
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, *n* (%)				
Married/de facto	71 (67)	23 (72)	12 (75)	11 (69)
Single/widowed/ divorced	35 (33)	9 (28)	4 (25)	5 (31)
Treated side, *n* (%)				
Dominant	53 (50)	19 (59)	8 (50)	11 (69)
Nondominant	53 (50)	13 (41)	8 (50)	5 (31)
Years since breast cancer treatment, *n* (%)				
6 months to 5 yr	57 (54)	10 (31)	5 (31)	5 (31)
>5 yr	49 (46)	22 (69)	11 (69)	11 (69)
Adjuvant treatment (yes), *n* (%)				
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, *n* (%)				
All nodes removed	30 (28)	10 (31)	6 (38)	4 (25)
1+ (unsure how many)	76 (72)	22 (69)	10 (63)	12 (75)
Years since lymphedema diagnosis, *n* (%)				
<1 yr	18 (17)	3 (9)	2 (13)	1 (7)
1–5 yr	47 (44)	15 (47)	6 (38)	9 (64)
>5 yr	23 (24)	12 (38)	8 (50)	4 (29)
Current lymphedema treatment, *n* (%)				
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)
Other	4 (4)	1 (4)	1 (6s)	0 (0)

P values not shown but all were greater than 0.10.
[a] Children in care: reflects the number of children currently being cared for within the family.
[b] 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.

We also recorded the number of supervised sessions attended per participant as well as the reasons given for periods of absence. Qualitative comments regarding the program and the lymphedema status provided by the women during exercise sessions were recorded. Together, exercise adherence rates and qualitative comments were used to provide insight into the acceptability of the program. 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 lymphedema treatment was collected. Women also responded to prompts, such as "you may wish to tell us what having lymphedema feels like, what do you think caused your lymphedema, whether certain activities aggravate or improve your lymphedema" in the questionnaire.

Statistical analysis. Lymphedema values as assessed by BIS (ratios) and perometry (volumes in milliliters) 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 SD 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 the 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 yr previously (Table 2). The IG and the CG also reported comparable patient and treatment characteristics at baseline, with mean age approximately 60 yr, about half reporting low levels of education and more than two thirds being in a significant relationship, with children. At T1, breast cancer was diagnosed more than 5 yr ago for 70% of IG and CG, whereas about half of the CG but only one third of the IG experienced lymphedema for more than 5 yr. Lymphedema treatment characteristics of the groups were similar, and comparable behaviors (specifically, adherence to "common" lymphedema prevention guidelines) at baseline were also observed (data not shown).

Lymphedema. There were no significant differences in lymphedema status at baseline or changes between testing phases observed between the IG and the CG. Mean impedance ratios at T1 were 1.13 ± 0.15 for the IG and 1.13 ± 0.19 for the CG, whereas 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 the CG, respectively (Table 3). With perometry, baseline volume differences for the IG and the CG were 337 ± 307 and 377 ± 416 mL, respectively. Mean volume changes between testing phases were insignificant

TABLE 3. Changes observed in lymphedema between pre- and postintervention and preintervention and 3-month follow-up.

Measures of Lymphoedema	*N*	Change between T1[a] and T2[b] Mean (SD)	Change between T1[a] and T3[c] Mean (SD)	*P* Values
BIS (ratio)				
CG	16	−0.00 (0.09)	0.01 (0.09)	0.75
IG	15	−0.01 (0.06)	0.02 (0.07)	0.88
Perometry (volume, mL)				
CG	16	43 (97)	19 (73)	0.35
IG	15	13 (81)	2 (71)	0.53

[a] T1, preintervention.
[b] T2, postintervention.
[c] T3, 3-month follow-up.

and ranged from 2 mL (IG: T1–T3) to 43 mL (CG: T1–T2) (Table 3).

Bioimpedance spectroscopy. Evaluation of individual lymphedema status by BIS at each of the three testing phases demonstrated that 9 (56%) of 16 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 lymphedema (ratio declined by 0.10 and 0.15). One IG participant experienced a significant increase in swelling throughout the study period (ratios/volumes; T1: 1.16/689 mL; T2: 1.47/923 mL; T3: 2.25/1870 mL). This participant attended 50% of the group-supervised sessions (sessions 1–8, 10, and 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 lymphedema became worse midway through her illness period. Since completion of the study, this participant continued to experience worsening lymphedema 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 lymphedema status were found in those who participated more completely and at higher intensities in the intervention. In regard to the CG, six women (38%) had measurable evidence of the condition at T1 and T3. An additional woman had measurable evidence of lymphedema at T2; however, her ratio declined again to within "normal" by T3. One (6%) of the 16 women 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 (60%) out of 15 and 8 (57%) out of 14 IG women had measurable evidence of lymphedema at T1 and T3, respectively, whereas 9 (56%) out of 16 and 10 (67%) out of 15 CG women had evidence of lymphedema at T1 and T3, respectively. Fluctuations of more than 10% volume difference between the treated and the untreated sides were observed for individuals in both groups, irrespective of lymphedema 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 gynecological 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, whereas data were unavailable for two participants (one in the IG and one in the CG) at T3. To ensure that the missing data did not contribute to results found, data analysis was repeated excluding these two participants, and no differences in results were observed (data not shown).

Qualitative data. Comments recorded on the self-reported questionnaire revealed one overarching concern: *lymphedema 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 lymphedema 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

TABLE 4. Prominent themes emerging from participant written or verbal comments (both IG and CG).

Themes	Illustrative Quotes
Pervasive impact of lymphedema	"...it [lymphedema] affects some capacity of every day-to-day activity."
	"Feel like my whole body is affected by this lymphedema."
	"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 [lymphedema]—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 of greater well-being	"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 exacerbate the lymphedema."
	"I felt the lymphedema 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 lymphedema" heavy or repetitive use and heavy lifting featured in responses (two in the IG, two 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."

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 lymphedema, 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 lymphedema and that change in arm symptoms is related to worsening lymphedema status were also evident. One third of the IG (six women) became concerned during the intervention because their arm symptoms were changing and thought this was indicative of their lymphedema progressing. As a consequence, we conducted a reassessment by BIS around week 6. At that time, five of the six women showed clinical improvements, whereas the other woman showed no change. The results gave the women reassurance and confidence that their arms were not adversely changing.

DISCUSSION

The use of the treated arm after breast cancer treatment and the potential to influence risk of developing lymphedema are topics with limited evidence driving clinical recommendations. Although 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 (32), and participating in physical activity activates the muscle pump mechanism. This single-blind, RCT sought to evaluate the effect of participating in a 12-wk supervised-exercise program on lymphedema status among women previously diagnosed with clinical lymphedema after breast cancer.

No group changes were observed in lymphedema status over the study period, although two (22%) of nine IG women 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 lymphedema, and that at minimum, 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 predominantly at moderate to high intensities. No adverse changes on lymphedema status have been reported by others who have also examined the effect of mixed-type exercise programs (aerobic and resistance based) (21,33) or resistance-based exercise alone (2) set at moderate intensities. These are important findings because 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 (6,11,30), lymphedema after breast cancer (10,14,16,25), and reduced survival after breast cancer (1,17,18). Therefore, although exercise currently lacks an evidence base in support of managing lymphedema, its indirect role in maintaining healthy lifestyles and body weight after breast cancer as well as minimizing risk of recurrence and optimizing survival should not be overlooked.

As noted earlier, lymphedema for one participant in the IG 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 breast cancer recurrence. Whether her progression of lymphedema was coincidental with progression of disease or provided an early sign is unknown but potentially worthy of future consideration.

The profound effects that lymphedema may have on a woman life's have been previously described (29). Gross and fine motor skills can be affected (27), impacting work, home, and personal care functions as well as recreational activities and social relationships (24). Other physical symptoms may include feelings of discomfort, heaviness, pain, tenderness, and aching, and reports of multiple associated symptoms are common (23). In addition to physical symptoms, psychological distress, depression, and anxiety (5) as well as changes in body image and self-image have been reported, with dressing concerns reflecting one practical issue (34). The women in this study have further confirmed that lymphedema 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 lymphedema brings with it a degree of social isolation because 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 lymphedema is another.

Although the fear associated with the risk of developing lymphedema has been previously reported (26), the women in this study emphasized that those with lymphedema continue to live with fear—fear that their lymphedema 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 lymphedema are of how their lymphedematous side feels and how capable they are of identifying changes in arm symptoms. Changing arm symptoms led to unplanned assessment of lymphedema status midway through the intervention for six 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 was 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. Of note, average attendance by the IG was more than 70% of supervised sessions and there were no withdrawals. Therefore, under the "right" conditions, it seems participation in exercise is acceptable to women with lymphedema.

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 (19), no relationship between garment use and change in lymphedema status was identified. Although 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, lymphedema, 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. Nonetheless, the study was adequately powered to detect statistically significant changes in our primary outcome. Although 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 lymphedema. Also, 38% of the sample lacked measurable evidence of lymphedema at baseline. It is therefore plausible that the intervention effect (positive or negative) on lymphedema status would be more difficult to observe. Nonetheless, this was an RCT, with the IG and the CG participants similar in personal, treatment, and behavioral 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 lymphedema 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.

The authors acknowledge Professor Beth Newman for her contributions to the study and manuscript, Sheree Harrison and Elizabeth Winkler for statistical analysis, the National Breast Cancer Foundation for funding Dr. Hayes' fellowship, and the women who made this research possible. The results of the current study do not constitute endorsement by ACSM.

REFERENCES

1. Abrahamson PE, Gammon MD, Lund MJ, et al. Recreational physical activity and survival among young women with breast cancer. *Cancer*. 2006;107(8):1777–85.
2. Ahmed RL, Thomas W, Yee D, Schmitz KH. Randomized controlled trial of weight training and lymphedema in breast cancer survivors. *J Clin Oncol*. 2006;24(18):2765–72.
3. Australian Institute of Health and Welfare. *Australia's Health 2004*. Canberra: AIHW; 2004. p. 528.
4. Borg GAV. Psychological bases of physical exertion. *Med Sci Sport Exer*. 1982;14:377–81.
5. Carter BJ. Women's experiences of lymphoedema. *Oncol Nurs Forum*. 1997;24(5):875–82.
6. Cleveland RJ. Weight gain prior to diagnosis and survival from breast cancer. *Cancer Epidemiol Biomarkers Prev*. 2007;16(9):1803–11.
7. Cornish B, Chapman M, Hirst C, et al. Early diagnosis of lymphedema using multiple frequency bioimpedance. *Lymphology*. 2001;34(1):2–11.
8. Courneya K, Mackey JR, McKenzie DC. Exercise after breast cancer: research evidence and clinical guidelines. *Phys Sportsmed*. 2002;30:33–42.
9. Courneya KS. Exercise in cancer survivors: an overview of research. *Med Sci Sport Exer*. 2003;35(11):1846-52.
10. Edwards TL. Prevalence and aetiology of lymphoedema after breast cancer treatment in southern Tasmania. *Aust N Z J Surg*. 2000;70:412–8.
11. Friedenreich C. Review of anthropometric factors and breast cancer risk. *Eur J Cancer Prev*. 2001;10:15–32.
12. Friedenreich CM, Courneya KS. Exercise as rehabilitation for cancer patients. *Clin J Sport Med*. 1996;6:237–44.
13. Harris SR, Niesen-Vertommen SL. Challenging the myth of exercise-induced lymphodema following breast cancer: a series of case reports. *J Surg Oncol*. 2000;74:95–9.
14. Hayes S, Cornish B, Newman B. Comparison of methods to diagnose lymphoedema among breast cancer survivors: 6-month follow-up. *Breast Cancer Res Treat*. 2005;89(3):221–6.
15. Hayes S, Newman B. Exercise in cancer recovery: an overview of the evidence. *Can Forum*. 2006;30(1):13–7.
16. Hayes SC, Janda M, Cornish B, Battistutta D, Newman B. Lymphoedema following breast cancer: incidence, risk factors and effect on upper body function. *J Clin Oncol*. 2008;26(10):DOI: 10.1200/JCO.2007.14.4899.
17. Holick CN, Newcomb PA, Trentham-Dietz A, et al. Physical activity and survival after diagnosis of invasive breast cancer. *Cancer Epidemiol Biomakers Prev*. 2008;17(2):379–86.
18. Holmes M, Chen W, Feskanich D, Kroenke C, Colditz G. Physical activity and survival after breast cancer diagnosis. *JAMA*. 2005;293(20):2479–86.
19. Johansson K, Tibe K, Weibull A, Newton RC. Low intensity resistance exercise for breast cancer patients with arm lymphedema with or without compression sleeve. *Lymphology*. 2005;38(4):167–80.
20. Lane K, Jespersen D, McKenzie DC. 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.* 2005;14(4):353–8.
21. McKenzie DC, Kalda AL. Effect of upper extremity exercise on secondary lymphedema in breast cancer patients: a pilot study. *J Clin Oncol.* 2003;21(3):463–6.
22. Mirolo BR, Bunce IH, Chapman M, et al. Psychosocial benefits of post-mastectomy lymphoedema therapy. *Cancer Nurs.* 1995; 18(3):197–205.
23. Moffatt CJ, Franks PJ, Doherty DC, et al. Lymphodema: an underestimated health problem. *Q J Med.* 2003;96(10):731–8.
24. Passik SD, McDonald MV. Psychosocial aspects of upper extremity lymphedema in women treated for breast carcinoma. *Cancer.* 1998;83:2817–20.
25. Petrek JA. Lymphedema in a cohort of breast carcinoma survivors 20 years after diagnosis. *Cancer.* 2001;92:1368–77.
26. Petrek JA, Heelan MC. Incidence of breast carcinoma-related lymphedema. *Cancer.* 1998;83:2776–81.
27. Rymal C. Lymphedema management in patients with lymphoma. *Nurs Clin North Am.* 2001;36(4):709–34.
28. Stevinson C, Lawlor DA, Fox KR. Exercise interventions for cancer patients: systematic review of controlled trials. *Cancer Causes Control.* 2004;15:1035–56.
29. Thomas-MacLean R, Miedema B, Tatemichi SR. Breast cancer-related lymphedema: women's experiences with an underestimated condition. *Can Fam Physician.* 2005;51:246–7.
30. Thune I, Furberg A. Physical activity and cancer risk: dose–response and cancer, all sites and site-specific. *Med Sci Sport Exer.* 2001;33(6 Suppl):S530–50.
31. Tobin MB, Lacey HJ, Meyer L, Mortimer PS. The psychological morbidity of breast cancer related arm swelling: psychological morbidity of lymphoedema. *Cancer.* 1993;72:3248–52.
32. Tortora GJ. *Principles of Human Anatomy.* 6th ed. New York (NY): Harper Collins; 1992. xix, 788. p. 84.
33. Turner J, Hayes SC, Reul-Hirche H. 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.* 2004; 86(3):141–6.
34. Woods M. Patients' perceptions of breast cancer related lymphoedema. *Eur J Cancer.* 1993;2:125–8.