■ CNE Article

Pilates for Breast Cancer Survivors:
Impact on Physical Parameters and Quality of Life After Mastectomy

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Pilates has been advocated for rehabilitation of breast cancer survivors despite little scientific evidence. The authors of this article have examined the feasibility of a Pilates program in postmastectomy breast cancer survivors and the impact on physical and psychological parameters. Fifteen breast cancer survivors were recruited in a one-arm study of 12 weeks of Pilates exercises. The authors assessed recruitment, adherence, and attrition, and measured changes in shoulder and neck range of motion, posture, height, arm volume, quality of life, mood, and body image from pre- to postintervention. Of 26 eligible patients, 15 enrolled, 13 completed the study, and 10 performed more than 50% of the recommended sessions. Statistically significant improvements emerged for shoulder abduction and internal rotation on the affected side, neck rotation toward the unaffected side, and neck flexion. The affected side arm volume and the interlimb volume discrepancy increased. Significant improvements were reported in quality of life, mood, and body image. The improvements in physical and psychological outcomes are promising and deserve further evaluation in a randomized, controlled study. The increase in affected arm volume also warrants additional investigation.

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For women in the United States, breast cancer is the leading cancer diagnosis and second most frequent cause of cancer-related deaths. Despite increasing survival rates, the disease and its treatment continue to burden survivors with adverse sequelae such as upper extremity impairment, lymphedema, fatigue, depression, weight gain, and immune system dysfunction (Cheville & Tchou, 2007; Demark-Wahnefried et al., 2001; Karki, Simonen, Malkia, & Selfe, 2005; Rietman et al., 2003). Some studies have indicated that patients who undergo mastectomy experience a lower quality of life (QOL) and more shoulder morbidity compared to patients who undergo lumpectomy (Engel, Kerr, Schlesinger-Raab, Sauer, & Holzel, 2004; Nesvold, Dahl, Lokkevik, Mengshoel, & Fossa, 2008; Skrzypulec, Tobor, Drosdzol, & Nowosielski, 2009).

Evidence shows that physical activity in general improves QOL, mood, fatigue, body image, and fitness (Courneya et al., 2007; Galvao & Newton, 2005; Knols, Aaronson, Uebelhart, Fransen, & Aufdemkampe, 2005; McCausland, 2010; McNeely et al., 2006; Ohira, Schmitz, Ahmed, & Yee, 2006; Pinto et al., 2008; Stevinson, Lawlor, & Fox, 2004) and may contribute to primary and secondary breast cancer prevention (Friedenreich, Gregory, Kopciuk, Mackey, & Courneya, 2009; Holmes, Chen, Feskanich, Kroenke, & Colditz, 2005; Peters et al., 2009). Despite this, a structured approach to physical exercise after breast cancer treatment is neither routinely recommended by

providers nor regularly performed by patients (Bellizzi, Rowland, Jeffery, & McNeel, 2005; Blanchard, Courneya, & Stein, 2008; Irwin et al., 2004).

Mindfulness and mind-body exercises such as yoga, t'ai chi, and Pilates are growing in popularity nationally. Pilates is the fastest growing fitness method (450% growth since 2000), with 8.6 million Americans participating regularly (Rovell, 2010). A search of Google.com on March 1, 2012, for *Pilates* and *breast cancer* identified 2,250,000 sites addressing Pilates exercises in breast cancer survivors.

The Pilates method consists of exercises inspired from yoga, karate, Zen meditation, and the ancient Greek and Roman philosophies of achieving physical and mental perfection (Levine, Kaplanek, Scafura, & Jaffe, 2007; Shand, 2004). Pilates strengthens the core muscles, which, subsequently, can lead to improvement in spine flexibility and posture (Kloubec, 2010). Despite more than 50 peer-reviewed publications about the benefits of Pilates in health-related conditions (back pain, orthopedic rehabilitation, fibromyalgia, and QOL in older adults) (Altan, Korkmaz, Bingol, & Gunay, 2009; Levine, Kaplanek, & Jaffe, 2009; Rydeard, Leger, & Smith, 2006; Siqueira Rodrigues, Ali Cader, Bento Torres, Oliveira, & Martin Dantas, 2010), only two studies have addressed the benefits and risks of Pilates exercises in breast cancer survivors (Eyigor, Karapolat, Yesil, Uslu, & Durmaz, 2010; Keays, Harris, Lucyshyn, & MacIntyre, 2008).

In the Rochester, MN, area (where patients were recruited from), Pilates, yoga and t'ai chi classes are widely available through several athletic centers; some of the classes are targeted to breast cancer survivors. A majority of the authors, at the time of the study, worked in a high-volume multidisciplinary breast diagnostic clinic dealing with newly diagnosed patients as well as survivors of breast cancer. Given the rising popularity of Pilates exercise nationwide (Rovell, 2010) and the interest expressed by a large number of patients on the safety and effectiveness of these methods in recovery and survival, the authors decided to investigate this further. A multidisciplinary team was formed that included breast specialists (internal medicine physicians with expertise in breast care), a psychologist, a Pilates instructor, a breast surgeon, a plastic surgeon, a physical medicine and rehabilitation specialist, physical therapists, and two nurse educators who helped with study coordination and patient consent.

A pilot study was conducted to assess the feasibility of Pilates exercises following mastectomy. Secondary aims included changes in shoulder range of motion (ROM), neck flexibility, posture, lymphedema, height, QOL, mood, and body image.

FIGURE 1. Mat Pilates Class

Note. Photo courtesy of the Mayo Clinic. Used with permission.

Methods

Participants

From June 2009 to November 2009, participants were recruited from the breast clinic at the Mayo Clinic in Rochester, MN, or were self-referred via advertising. Women treated with mastectomy for stage I–IIIA breast cancer between the ages of 30–80 years were eligible for participation. Medical clearance was obtained from the treating surgeons and women were 6–52 weeks postmastectomy. Women with osteoporosis, regular Pilates participants, those who were pregnant, or those having acute herniated disk and acute or untreated psychiatric illness were excluded. The protocol was approved by the Mayo Clinic's institutional review board and written informed consent was obtained from all study participants.

Study Design

A prospective, interventional, one-arm, open-label study was conducted for 12 weeks on structured Pilates mat exercises for 15 breast cancer survivors having undergone mastectomy.

Outcome Measures

Primary outcomes were feasibility and adherence (i.e., accrual, retention, attrition, and treatment acceptability). Adherence was documented by the Pilates instructor and the study participants on a weekly basis. Compliance was defined as participation in more than 75% of the 36 recommended sessions (about 27 sessions or more). A brief postintervention open-ended questionnaire addressing satisfaction with the study design, level of exercises, and potential side effects or benefits was distributed.

Physical outcomes: Physical outcomes were assessed at baseline and after the intervention for the following parameters: active shoulder ROM (goniometric measurement in supine position of forward flexion, abduction, external, and internal rotation), neck flexibility (goniometric measurement of active cervical ROM) in seated position, posture (measurement of thoracic kyphosis, lumbar lordosis, and shoulder protraction), and height (standing tall on a standard clinical scale using the attached height rod). Impaired shoulder ROM was defined as a difference of 20° or greater between the unaffected and affected side shoulders (patients with bilateral breast cancer [n = 3] were excluded from this analysis). All measurements were conducted concurrently by two physical therapists.

Lymphedema was assessed by perometry, an optoelectronic limb volumeter with well-validated accuracy, precision, and reproducibility (Stanton, Northfield, Holroyd, Mortimer, & Levick, 1997). The perometer uses infrared lamps and photo sensors. The scanner is comprised of (a) the frame around the arm that contains all the electronic parts, (b) an arm support, and (c) a rail on which the frame slides. Obtaining a perometric image requires only 30 seconds. Harmless infrared light beams are first directed vertically as the frame surrounding the limb slides along the track. The failure of beams to reach the sensors on the opposite side of the frame, having been blocked by the extremity, is recorded by the computer. As the frame slides backward around the extremity, beams are directed horizontally across the frame. The computer records those beams that are intercepted by the

Warm Up

- **Standing roll down (2 reps)**
  Objective: motivation, focus, view form, centering
- **Breathing (4 breaths)**
  Objective: feeling present
- **Pelvic rock (2–4 reps)**
  Objective: prepare for pelvic curl, relax lower back
- **Pelvic curl (6–10 reps)**
  Objective: warm up spine, spinal articulation

Core Exercises

- **Pro- and retract shoulders, ab- and ad-duct arms (6 reps)**
  Objective: stabilize scapula, open oneself to session
- **Spine twist supine (8 reps)**
  Modify: feet flat with legs together
  Objective: core strengthening, spinal rotation
- **Chest lift: first set (6 reps)**
  Modify: fingers to knees
  Add: rotation with upper body down between rotation to each side
  Objective: fundamental movement for core strengthening, lateral flexion, and rotation
- **Single leg lifts (5 for each leg)**
  Add: leg changes
  Objective: pelvic-lumbar stabilization
- **Hundred (100 count)**
  Add: lift head and chest
  Objective: stimulates body circulation and body heat

Transition: Roll up

- **Half roll back (6 reps)**
  Objective: core strength, balance, spinal mobility

Transition: Roll down onto mat

- **Roll up (8–10 reps)**
  Modify: bent knees, hand weights
  Objective: abdominal strength, spinal mobility, and stability

Transition: Release balls and roll down onto mat

- **Leg circles (5 each leg in both directions)**
  Modify: flex at knees
  Inhale around, exhale around
  Objective: pelvic-lumbar stability, hip mobilization

Transition: Roll up

- **Rolling like a ball (6–10 reps)**
  Modify: balance only
  Objective: spinal flexion
- **Chest lift: second set (6 reps)**
  Modify: fingers to knees
  Add: rotation with upper body down between rotation to each side
  Objective: fundamental movement for core strengthening, lateral flexion, and rotation
- **Double leg stretch (6–10 reps)**
  Add: arms overhead on diagonal
  Objective: outer growth, abdominal strengthening, trunk stabilization

Transition: Roll up

- **Single leg lifts (5 reps)**
  Objective: focus on core, abdominal strengthening
- **Criss cross (3–5 sets)**
  Objective: oblique development

Transition: Roll up

- **Spine stretch (6 reps)**
  Objective: spinal articulation, trunk stabilization
- **Saw (3–5 reps on each side)**
  Use back hand for support
  Objective: spinal rotation, hamstring stretch
- **Sitting spine twist (6–8 reps)**
  Objective: spinal rotation, oblique development

Transition: Roll down, lengthen left arm and leg, and roll onto side

- **Side leg lifts (8–10 reps on each side)**
  Objective: core stability, balance, strengthening lateral flexors
- **Oblique arch (8–10 reps on each side)**
  Add: abductor lift and adductor squeeze
  Oblique arch on left side, then swing legs to right to repeat single leg lifts and oblique arch on right
  Objective: core stability, balance, strengthening lateral flexors

Transition: Roll to side and then prone

- **Basic swan (8–10 reps)**
  Add: full extension
  Objective: back extensor strength
- **Swimming (40–100 count)**
  Modify: hands on mini flex ball
  Add: full swimming
  Objective: core strength and stability, coordination
- **Rest position (3–5 breaths)**
  Objective: stretch lumbar spine, release shoulder and arm tension
- **Cat stretch (3–5 reps)**
  Initiate from crown of head
  Objective: lengthen lumbar spine, back extensor strength
- **Teaser prep (3 reps)**
  Tabletop with knees bent
  Modify: lift upper body; omit balance
  Objective: core stability, spinal flexion, balance

Cool Down

- **Turn head right, bend knees left and reverse (2 reps on each side)**
  Objective: release tension in neck and lumbar spine
- **Pelvic rock with circles (2 reps)**
  Add: rock side to side through imprint
  Objective: relax hips and pelvis
- **Standing roll down (2 reps)**
  Objective: motivation, focus, view form, centering

FIGURE 2. Pilates Mat Repertoire for Instructor-Led Group Class

limb. In this manner, the volume within the frame that is displaced by a limb can be accurately calculated. The perometer has been extensively used in studies of lymphedema in patients with breast cancer (Göltner, Fischbach, Mönter, Kraus, & Vorherr, 1985; Stout Gergich et al., 2008) and perometric measurements of the limbs are used in the guidelines for diagnosing and treating lymphedema (Cheville et al., 2003).

The authors acknowledged the persistent controversy regarding volumetric criteria for arm lymphedema by examining incidence rates using a range of proposed diagnostic approaches (Armer, Stewart, & Shook, 2009). Lymphedema was defined as interlimb volume discrepancy ([affected limb volume–unaffected limb volume]/unaffected limb volume) of 5% or greater (Cheville et al., 2003), and subclinical lymphedema as affected side limb volume increase ([affected limb volume postintervention–affected limb volume at baseline]/affected limb volume at baseline) of 3% or greater (Stout Gergich et al., 2008). Emerging definitions of lymphedema, such as 5% or greater increase in interlimb volume discrepancy ([interlimb volume discrepancy postintervention–interlimb volume discrepancy at baseline]/interlimb volume discrepancy at baseline) also were considered (Schmitz, 2010). All measurements were conducted by one lymphedema specialist. Lymphedema symptoms were assessed with the Norman Lymphedema Questionnaire, a validated, self-reported measure that permits detection of signs and symptoms of lymphedema in patients with breast cancer (Norman, Miller, Erikson, Norman, & McCorkle, 2001).

Psychological outcomes: Breast cancer-specific QOL was assessed by the Functional Assessment of Cancer Therapy–Breast (FACT-B) questionnaire (Brady et al., 1997). Mood was assessed using the Profile of Mood States (POMS) short form (McNair, Lorr, & Droppleman, 1992), and body image was assessed by the Multidimensional Body-Self Relations Questionnaire (MBSRQ) (Cash, 2000). Higher scores represented better outcomes in all the psychological subscales. Changes in these scales were compared to the available minimally important difference to assess for clinical significance (Eton et al., 2004). An effect size of 0.5 standard deviations or greater was considered clinically significant (Norman, Sloan, & Wyrwich, 2003).

Intervention

Participants were instructed on the philosophy and principles of the Pilates method and participated in one instructor-led class at the beginning of the study (see Figure 1). The mat Pilates method was used—an introductory level class that focuses on core muscle strengthening and spine flexibility. Modifications were offered as needed. The classes' repertoire (see Figure 2) was coordinated by a Pilates Method Alliance certified instructor, with additional consultation by a master Pilates teacher. Participants could choose to attend the Pilates classes at an exercise facility affiliated with the Mayo Clinic or perform the exercise at home using a provided DVD with a similar repertoire as the Pilates classes. Free membership to the exercise facility was provided.

The participants were asked to perform the 45-minute Pilates exercises twice weekly for the first four weeks, three times weekly for the next four weeks, and four times weekly for the last four weeks (a total of 36 sessions). Descriptive analyses were used to express participant recruitment, intervention adherence, and attrition. Outcome measures were expressed using mean and standard deviation. Pre- and postintervention comparisons were performed by paired t test and confirmed by nonparametric testing, given the small sample size and nonuniform distribution of many variables. Only per-protocol analyses were performed given the experimental nature of the study. Statistical analyses were handled by SAS/STAT, version 9.1.3, software. Any p value of 0.05 or less (two-sided) was considered statistically significant.

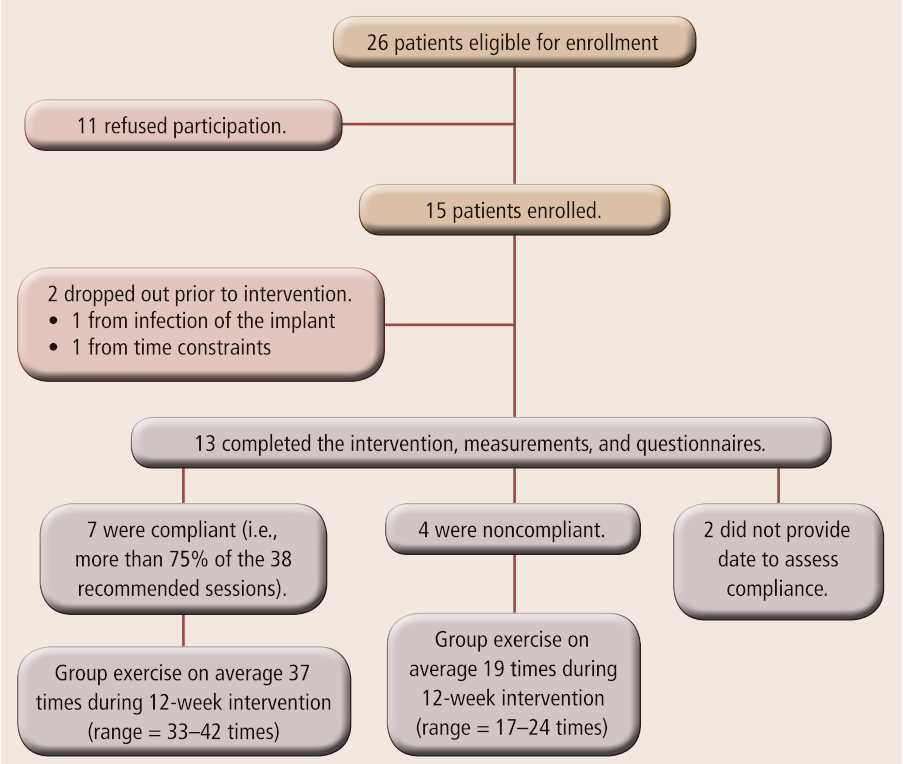

FIGURE 3. Study Enrollment, Adherence, and Attrition

Results

Patients

To enroll 15 patients, the authors screened 27 patients and identified 26 as eligible, representing a recruitment rate of 58%. Thirteen (87%) completed the study (see Figure 3), and two withdrew prior to starting the intervention. Table 1 shows baseline characteristics of the 26 eligible patients and compares those who participated and those who declined study enrollment. Compared with the patients who refused participation (n = 11),

a trend was noted toward participants having a higher likelihood of breast reconstruction, having had unilateral (versus bilateral) mastectomy, having received radiation therapy at the time of screening, and having completed chemotherapy at the time of screening.

The participants with bilateral axillary surgery (n = 3) and one without postintervention ROM measurements of the affected arm were excluded from interlimb ROM analyses (n = 9). The participants with bilateral axillary surgery were included (each with two measurements) on the affected arm ROM (n = 15) and arm volume measurements (n = 16).

Feasibility

The 13 patients who participated in the intervention attended 74% (339 out of 468) of the recommended Pilates sessions. Seven (54%) performed more than 75% of the 36 recommended sessions, four (31%) performed between 47%–75% of the recommended sessions, and two (15%) did not provide data regarding the frequency of participation. The mean number of classes attended was 31 (range = 17–42). On average, home participation was 19 sessions (range = 6–33 classes) and gym participation was 12 classes (range = 4–22 classes). Three participants were restricted from participation for two to three weeks of the study because of radiation skin reaction (n = 2) and implant exchange surgery (n = 1).

Seven patients (54%) returned the brief postintervention survey. All answered positively to the question whether or not the Pilates exercises were enjoyable, and all stated that the level of exercises were "just right" on a scale with options from "too easy," to "just right," to "too hard to perform." No side effects were reported. Three respondents commented on the benefits of Pilates as a whole body workout, and one noted significant improvement in her urinary incontinence symptoms. The most common barriers to exercising were work or weather interfering with Pilates classes (n = 5), busy life schedule (n = 2), and radiation skin reaction (n = 1).

Changes in Physical Parameters

Overall, shoulder mobility improved for all the movements in both shoulders (see Table 2). Statistically significant improvements were seen only on the affected side shoulder for abduction ($\bar{X}$ change = 22.6°, SD = 23.6°; p = 0.002) and internal rotation ($\bar{X}$ change = 5.8°, SD = 9.2°; p = 0.028). At baseline, four participants (40% of those eligible) had impaired ROM in at least one of the shoulder movements (interlimb difference range 20°–49°). Of these, three normalized shoulder mobility after intervention (range = 0°–18°), and one developed additional limitations in abduction and developed new impairments in flexion and external rotation. No other participants developed shoulder impairment postintervention.

Significant improvements were seen in the neck rotation toward the unaffected side ($\bar{X}$ change = 5.7°, SD = 2.8°; p < 0.001) and neck flexion ($\bar{X}$ change = 3.5°, SD = 5.6°; p = 0.046). No statistically significant difference was noted in the posture measurements and in height. Arm volume outcomes are presented in Tables 3 and 4. The mean interlimb volume discrepancy of patients with unilateral axillary surgery (n = 10) increased over the 12-week study interval such that their affected arms became larger relative to their unaffected arms (–1.2% at baseline versus 0.4% at week 12; p = 0.024). On average, interlimb volume discrepancy increased by 1.6% (range = –1.1% to 4.7%).

Based on the 5% interlimb discrepancy threshold (Cheville et al., 2003), one patient had lymphedema at baseline; she experienced a 1.3% increase in interlimb volume difference postintervention and her lymphedema-related symptoms worsened. One

TABLE 1. Baseline Characteristics of Study Participants and Patients Who Declined Participation

	Participants (N = 15)			Eligible But Declined Participation (N = 11)		
Characteristic	$\bar{X}$	SD	Range	$\bar{X}$	SD	Range
Age (years)	49	9	33–65	51	14	33–74
Months since surgery	5.7	–	1–11	6	–	2–11
Characteristic		**n**			**n**	
Race						
Caucasian		14			10	
Asian		1			1	
Cancer histology						
Invasive ductal carcinoma		8			10	
Ductal carcinoma in situ		3			1	
Other		4			–	
Cancer stage						
0		3			1	
I		3			5	
II		7			3	
III		2			2	
Type of breast surgery						
Bilateral mastectomy		10			10	
Unilateral mastectomy		5			1	
Type of axillary surgery						
Sentinel lymph node		11			6	
Axillary dissection		4			5	
Reconstruction						
Bilateral		8			4	
Unilateral		3			–	
None		4			7	
Radiation therapy (chest wall and/or axilla)						
Total		6			3	
At screening		3			–	
Adjuvant therapies						
Chemotherapy total		9			8	
Chemotherapy at screening		1			4	
Hormonal therapy		7			3	
Trastuzumab		2			1	

Note. Participants could have multiple responses for the adjuvant therapies section.

Implications for Practice

- Pilates is the fastest-growing fitness method in the general population and is widely advertised for rehabilitation for breast cancer survivors.
- A program of Pilates exercises is feasible and can improve shoulder and neck mobility, quality of life, mood, and body image in breast cancer survivors after mastectomy.
- A trend toward subclinical lymphedema was seen in the current study; caution is recommended in implementing a program of Pilates exercises in women with risk factors for lymphedema postmastectomy.

patient developed new onset lymphedema per the 5% interlimb discrepancy threshold (Cheville et al., 2003) and the 5% increase in interlimb volume discrepancy threshold (Schmitz, 2010). When examined by a clinician experienced in lymphedema management, this patient, although having the greatest increase in interlimb volume discrepancy (4.7%), was not found to have clinical stigmata of lymphedema, and her lymphedema symptom score remained null. Six patients (40%) developed new onset subclinical lymphedema by the 3% or greater increase in the affected arm volume criteria (Stout Gergich et al., 2008). Among them, the lymphedema symptom score increased in one, decreased in one, and remained unchanged in the other four.

Self-Reported Quality of Life, Mood, and Body Image

Quality of life: Statistically and clinically significant improvements were seen in all of the FACT-B subscales except for the emotional well-being subscale. Based on the minimally important difference levels, the number of patients with an increase in QOL scores above the clinically significant level were 9 of 13 (total FACT-B score), 8 of 13 (total Outcome Index score), 9 of 13 (FACT-G score), and 8 of 13 (breast cancer subscale score).

Mood: Mean subscale and total scores on the POMS short form were higher postintervention than preintervention; however, only three of these were significant: vigor-activity, fatigue-inertia, and total mood disturbance (all, $p = 0.001$).

Body image: For the MBSRQ, improvements were reported on all of the subscales except for appearance orientation. Statistically and clinically significant changes were seen for the subscales of health evaluation ($p = 0.049$) and body area satisfaction ($p = 0.017$). The clinical significance mirrored the statistical significance in all the psychological outcomes measures (effect size of 0.5 or greater) (see Table 5).

Discussion

The principle findings of this study are that a structured program in Pilates method exercises are of interest to a clinically relevant (58%) proportion of patients following mastectomy for breast cancer, and that adherence to such a program was high (74% of the recommended sessions were attended) and attrition was low (13%). Significant improvements in physical parameters, including shoulder mobility, were observed, as were improvements in psychological parameters such as QOL, mood, and body image. Measures of lymphedema, however, suggested development of lymphedema in as many as six patients, depending on the criteria used, with an increase in affected arm volume relative to the unaffected side.

The rate of recruitment was comparable to other studies using convenience samples (greater than 60%) (Eyigor et al., 2010; Ohira et al., 2006), but exceeded that reported for other studies of physical activity in breast cancer survivors (Courneya et al., 2003, 2007; Irwin et al., 2008; Segal et al., 2001). That may be a reflection of genuine increased interest in such interventions among breast cancer survivors for this type of mind-body approach compared with traditional methods. Alternatively, it may simply be a reflection of the convenience sample method (Irwin et al., 2008).

The observed adherence to the program (54% performed 75% or more of recommended sessions) also is comparable to other studies of physical activity programs in this population of 56%–98% (Courneya et al., 2003, 2007; Irwin et al., 2008; Segal et al., 2001). The authors hypothesize, however, that the adherence would have been higher had three of the participants not been restricted in using their arms for a prolonged period because of radiation skin reaction (n = 2) or implant exchange

TABLE 2. Physical Assessment of Shoulder Range of Motion in Degrees and Prevalence of Shoulder Disability at Baseline and Postintervention

	Affected Shoulder							Unaffected Shoulder						
	Pre		Post		Change			Pre		Post		Change		
Motion	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	p[a]	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	p[a]
Abduction	139.6	25.2	162.2	19.8	23.4	24.3	0.002	151.8	26.4	167.2	11.4	15.1	25.1	0.12
External rotation	82.3	12.4	85.1	16.3	2.5	13.5	0.42	87.2	7.7	90.4	7	3.6	10.7	0.42
Flexion	155.2	9.51	157.9	12.4	2.9	11	0.34	161.2	8	165	9.5	3.4	10.1	0.32
Internal rotation	55.5	7.9	61.3	7.6	5.9	9.5	0.028	53.6	9.2	58.8	6.5	15.2	12	0.25

[a] Paired t test

Note. The number of patients with impaired range of motion (defined as 20° or greater between the unaffected and affected side shoulder mobility) was as follows: abduction (3 pre, 1 post), external rotation (1 post), and flexion (2 pre, 1 post).

TABLE 3. Limb Volumes at Baseline and Postintervention and Incidence of Lymphedema

			In Percent of Volume			
			Baseline	Postintervention		
Patient Study ID	Axillary Lymph Nodes Removed	Chest Wall or Nodal Radiation	Interlimb Discrepancy[a]	Interlimb Discrepancy[a]	Affected Limb Volume Change[b]	Interlimb Discrepancy Change
1	2		1.3	6	2.7	4.7
2	17	X	6.6	7.8	0.8	1.3
3	4		2.5	4.2	3.4	1.7
4 right	21	X	NA	NA	5.2	NA
4 left	25		NA	NA	6.7	NA
5	1		1	–0.1	1.7	–1.1
6	2		–6.8	–3.1	3.9	3.7
7	8	X	–5.5	–3.7	8.7	1.8
8	5		–1.2	0.4	–1.1	1.7
9 right	15	X	NA	NA	1.6	NA
9 left	2		NA	NA	2.8	NA
10	3	X	–5.2	–5.3	–1.8	–0.2
11	NA		–5.2	–2.1	5.6	3
12 right	6		NA	NA	0.1	NA
12 left	31	X	NA	NA	0.6	NA
13	2		0.5	–0.1	1.8	–0.6
Mean per group	–		–1.2	0.4	2.7	1.6

[a] To calculate interlimb discrepancy, (volume affected limb–volume unaffected limb)/volume unaffected limb
[b] To calculate percent change, (volume postintervention–volume at baseline)/volume at baseline
NA—not available; ID—identifier

(n = 1). Modification of the protocol for those situations might be warranted to ensure continuous participation.

The improvements in observed physical performance are consonant with the observations made by Eyigor et al. (2010) in their study of 52 women (51 of whom had undergone mastectomy) enrolled in a program of Pilates plus walking versus stretching plus walking. In Eyigor et al. (2010), statistically significant improvements were seen after the intervention in the six-minute walk test, depression, QOL, and functional scores for the Pilates group, but not in the control group. Postintervention between group analyses showed a statistically significant improvement in the six-minute walk test only, favoring the Pilates group. Fatigue and flexibility were not improved. The main outcomes of Eyigor et al. (2010) differ significantly from the current study, precluding a direct comparison.

An improvement in shoulder mobility was observed by the authors of the current study, similar to the improvement noted in four patients enrolled in Pilates reformer classes in Keays et al. (2008). The one-arm study by Keays et al. (2008) evaluated the effect of reformer Pilates exercises (an advanced Pilates method using a special apparatus comprised of weights and pulleys) on shoulder ROM in four patients after axillary dissection, and showed modest improvements in external rotation and abduction. The small size of Keays et al. (2008) limited its generalization. A comparison to the current study is limited because of the very different Pilates methods used. Others have noted such improvements in shoulder mobility as well with combined aerobic and resistive exercise (Cheema & Gaul, 2006). The current study had a high prevalence of shoulder impairment (40%), which was comparable to that reported by others (9%–51%) (Nesvold et al., 2008; Rietman et al., 2003). Shoulder impairment was linked to increased disability and decreased physical functioning. Springer et al. (2010) demonstrated that shoulder ROM returns to baseline one year after breast cancer surgery if physical therapy is implemented early. In the absence of randomized, controlled studies of physical activity addressing shoulder mobility in this population, discerning whether the improvements noted are from the effect of the intervention or other factors (i.e., the passage of time) is difficult.

TABLE 4. Incidence of Lymphedema

	New Onset Lymphedema by Different Lymphedema Definitions			
	Baseline	Postintervention		
Patient Study Identifier	5% or Greater ILD (N = 10)	New Onset (5% or Greater) ILD (N = 9)	3% or Greater Increase in ALV (Subclinical Lymphedema) (N = 15)	5% or Greater Increase in ILD (N = 9)
1		X		X
2	X			
3			X	
4 right			X	
4 left			X	
5				
6			X	
7			X	
8				
9 right				
9 left				
10				
11			X	
12 right				
12 left				
13				
Total	1/10 = 10%	1/9 = 11%	6/15 = 40%	1/9 = 11%

ALV—affected limb volume; ILD—interlimb discrepancy

Although many parameters were encouraging, an increase in interlimb volume differences was observed during the course of the study. The 1.6% mean increase in interlimb volume difference detected may not seem large, but is potentially concerning in light of the fact that at least one patient developed new onset lymphedema in her arm on the side of her surgery and another experienced worsening of established lymphedema. A high level of statistical significance ($p = 0.02$), despite the small sample size, argues that this increase in interlimb differences during the 12-week course of the study is not related to chance. In addition, depending on the diagnostic criteria, as many as six participants developed new onset subclinical lymphedema.

That finding differs from those of several investigators' reports that gentle, incremental, resistive exercise may prevent and ameliorate lymphedema (Ahmed, Thomas, Yee, & Schmitz, 2006; Schmitz et al., 2009). The cause of the discrepancy remains problematic, but one might posit that this difference may be explained by the fact that Pilates requires sustained isometric contractions of the periscapular and arm muscles at levels of intensity far above those of daily activities or light isometric exercise. It may be that the abrupt subjection of the participants' muscles to intense and sustained stress for which they were untrained is a potentially causative factor.

A threshold set by Stout Gergich et al. (2008) for diagnosing preclinical lymphedema is based on volume changes compared to preoperative arm volumes, whereas, in the current study, the limb measurements were taken postmastectomy and, therefore, the assessment of preclinical lymphedema might not be valid. The prevalence of lymphedema following primary breast cancer treatment increases with time from surgery, most acutely during the first three years and stabilizing thereafter (Norman et al., 2009). In the absence of a control group, it is impossible to definitively discern if the tendency toward lymphedema was caused by the Pilates exercises or the passage of time. In Eyigor et al. (2010), no lymphedema was reported in the Pilates or control group, although no details are given as to how lymphedema was defined and measured. Additional research is needed, but it may be difficult at this point to endorse Pilates as a safe form of exercise for women with and at risk for lymphedema.

As important as the physical improvements observed, the authors also saw improvements in QOL, mood, and body image. The identified improvements were similar to those seen in other exercise and mind-body interventions (Al-Majid & Gray, 2009; Berglund, Bolund, Gustafsson, & Sjoden, 1994; Cohen, Warneke, Fouladi, Rodriguez, & Chaoul-Reich, 2004; Hutnick et al., 2005; Kuchinski, Reading, & Lash, 2009; Merrithew, 2009; Mock et al., 2005; Stout Gergich et al., 2008). Group exercise interventions, such as Pilates, are particularly appealing options for a common condition such as breast cancer as they are inexpensive, easy to disseminate, can be used alongside other treatments, and have relatively few side effects (Duijts, Faber, Oldenburg, van Beurden, & Aaronson, 2011). In a review of the literature evaluating 43 studies of mind-body interventions for patients with cancer (Duijts et al., 2011), all but one reported benefits for mood. In addition, given a general concern among women regarding body image, with as many as 89% of women concerned about body weight (Cash, 2002), and evidence that interventions such as Iyengar yoga have been reported to improve body image (Al-Majid & Gray, 2009; Courneya, 2001; Hutnick et al., 2005; Mock et al., 2005), it is reasonable to conjecture that an intervention such as Pilates may be particularly useful after a surgical procedure with such obvious effects on outward appearance.

The current study has a number of limitations. Although the largest to date to assess the feasibility of using the Pilates method in breast cancer survivors and to report on shoulder function and arm volumes, the current study still is too small to know with any degree of certainty the significance of the lymphedema observed and to attribute the benefits observed to the intervention. Still, its prospective design, clearly defined exercise program, and multidisciplinary assessment design support the feasibility of performing a larger study with an appropriately defined control arm to evaluate the salutary ef-

TABLE 5. Outcomes Pre- and Postintervention for Quality of Life, Mood, and Body Image

Scale	Baseline		12 Weeks Later		Difference		Effect Size	p
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD		
FACT-B (quality of life)								
Physical well-being (PWB)	20.23	3.81	24.08	3.33	3.85	3.93	0.9	0.004*
Social or family well-being (SFWB)	19.97	7.72	22.59	7.75	2.62	4.22	0.62	0.045*
Emotional well-being (EWB)	18.62	2.93	20	1.29	1.38	3.66	0.38	0.2
Functional well-being (FWB)	19.08	4.44	22.19	4.76	3.12	4.8	0.65	0.037*
Factor-G (PWB + SFWB + EWB + FWB)	77.9	13.24	88.86	14.18	10.96	9.41	1.16	0.001*
Breast cancer subscale (BCS)	23.92	4.61	26.54	3.69	2.62	3.04	0.86	0.009*
Total score (Factor-G + BCS)	101.82	14.09	115.4	15.44	13.58	10.47	1.3	< 0.001*
Trial Outcome Index score (PWB + FWB + BCS)	63.23	9.32	72.81	8.75	9.58	7.85	1.22	< 0.001*
POMS (mood)								
Tension (anxiety subscale)	15.92	3.71	16.38	3.69	0.46	3.95	0.12	0.68
Vigor (activity subscale)	6.54	3.55	10.31	4.31	3.77	3.19	1.18	0.001*
Fatigue (inertia subscale)	12	3.06	16.62	4.17	4.62	3.84	1.2	0.001*
Depression (dejection subscale)	17.15	2.7	18	2.38	0.85	2.61	0.32	0.27
Confusion (bewilderment subscale)	16.08	2.78	16.92	1.98	0.85	2.23	0.38	0.2
Anger (hostility subscale)	17.77	2.42	18.31	2.36	0.54	2.9	0.19	0.52
Tension (anxiety POTR)	79.62	18.54	81.92	18.43	2.31	19.75	0.12	0.68
Vigor (activity POTR)	32.69	17.75	51.54	21.54	18.85	15.96	1.18	0.001*
Fatigue (inertia POTR)	60	15.28	83.08	20.87	23.08	19.21	1.2	0.001*
Depression (dejection POTR)	85.77	13.52	90	11.9	4.23	13.05	0.32	0.27
Confusion (bewilderment POTR)	80.38	13.91	84.62	9.89	4.23	11.15	0.38	0.2
Anger (hostility POTR)	88.85	12.1	91.54	11.79	2.69	14.52	0.19	0.52
POMS-SF total score (best = 120)	85.46	11.49	96.54	12.89	11.08	9.55	1.16	0.001*
POMS-SF POTR (best = 100)	71.21	9.57	80.44	10.75	9.23	7.97	1.16	0.001*
MBSRQ (body image)								
Appearance evaluation	2.88	0.8	3.29	0.74	0.41	0.74	0.55	0.07
Appearance orientation	3.42	0.62	3.42	0.73	0	0.3	0	1
Fitness evaluation	3.13	0.71	3.31	0.88	0.18	0.52	0.35	0.24
Fitness orientation	2.97	0.74	3.22	0.73	0.25	0.5	0.5	0.1
Health evaluation	3.22	0.89	3.6	0.87	0.38	0.63	0.6	0.049*
Health orientation	3.5	0.49	3.75	0.53	0.25	0.48	0.53	0.08
Illness orientation	3	0.57	3.25	0.7	0.25	0.49	0.5	0.1
Body area satisfaction	2.79	0.72	3.13	0.68	0.34	0.45	0.76	0.018*
Overweight preoccupation	2.15	0.86	2.23	0.79	0.08	0.74	0.1	0.71
Self-classified weight	3.77	0.83	3.42	0.95	–0.35	1.13	0.31	0.29

N = 13

* Denotes statistical significance

FACT-B—Functional Assessment of Cancer Therapy–Breast; MBSRQ—Multidimensional Body Self-Relations Questionnaire; POMS-SF—Profile of Mood States Short Form; POTR—percent of total raw

Note. For the FACT-B scale, the minimally important difference points are 5–6 for Factor-G, 2–3 for BCS, 7–8 for total score, and 5–6 for Trial Outcome Index.

fect simply of the passage of time. Expansion to a more socioeconomically and racially diverse population also is desirable.

A large number of breast cancer survivors likely practice Pilates. The authors have found this exercise method to be feasible and associated with both physical and psychological benefits; however, they also note lymphedema development in the participants. Randomized, controlled studies are, therefore, needed to further define the immediate and long-term risks and benefits of Pilates for breast cancer survivors.

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References

Ahmed, R.L., Thomas, W., Yee, D., & Schmitz, K.H. (2006). Randomized controlled trial of weight training and lymphedema in breast cancer survivors. *Journal of Clinical Oncology, 24,* 2765–2772. doi:10.1200/JCO.2005.03.6749

Al-Majid, S., & Gray, D.P. (2009). A biobehavioral model for the study of exercise interventions in cancer-related fatigue. *Biological Research for Nursing, 10,* 381–391. doi:10.1177/1099800408324431

Altan, L., Korkmaz, N., Bingol, U., & Gunay, B. (2009). Effect of pilates training on people with fibromyalgia syndrome: A pilot

study. *Archives of Physical Medicine and Rehabilitation, 90,* 1983–1988. doi:10.1016/j.apmr.2009.06.021

Armer, J.M., Stewart, B.R., & Shook, R.P. (2009). Thirty-month post-breast cancer treatment lymphoedema. *Journal of Lymphoedema, 4,* 14–18.

Bellizzi, K.M., Rowland, J.H., Jeffery, D.D., & McNeel, T. (2005). Health behaviors of cancer survivors: Examining opportunities for cancer control intervention. *Journal of Clinical Oncology, 23,* 8884–8893. doi:10.1200/JCO.2005.02.2343

Berglund, G., Bolund, C., Gustafsson, U.L., & Sjoden, P.O. (1994). One-year follow-up of the "Starting Again" group rehabilitation programme for cancer patients. *European Journal of Cancer, 30A,* 1744–1751.

Blanchard, C.M., Courneya, K.S., & Stein, K. (2008). Cancer survivors' adherence to lifestyle behavior recommendations and associations with health-related quality of life: Results from the American Cancer Society's SCS-II. *Journal of Clinical Oncology, 26,* 2198–2204. doi:10.1200/JCO.2007.14.6217

Brady, M.J., Cella, D.F., Mo, F., Bonomi, A.E., Tulsky, D.S., Lloyd, S.R., . . . Shiomoto, G. (1997). Reliability and validity of the Functional Assessment of Cancer Therapy–Breast quality-of-life instrument. *Journal of Clinical Oncology, 15,* 974–986.

Cash, T.F. (2000). The Multidimensional Body-Self Relations Questionnaire. MBSRQ user's manual (3rd rev.). Retrieved from www.body-images.com/assessments/mbsrq.html

Cash, T.F. (2002). Women's body images. In G.M. Wingood & R.J. DiClemente (Eds.), *Handbook of women's sexual and reproductive health* (pp. 175–194). New York, NY: Plenum.

Cheema, B.S., & Gaul, C.A. (2006). Full-body exercise training improves fitness and quality of life in survivors of breast cancer. *Journal of Strength and Conditioning Research, 20,* 14–21.

Cheville, A.L., McGarvey, C.L., Petrek, J.A., Russo, S.A., Thiadens, S.R., & Taylor, M.E. (2003). The grading of lymphedema in oncology clinical trials. *Seminars in Radiation Oncology, 13,* 214–225. doi:10.1016/S1053-4296(03)00038-9

Cheville, A.L., & Tchou, J. (2007). Barriers to rehabilitation following surgery for primary breast cancer. *Journal of Surgical Oncology, 95,* 409–418. doi:10.1002/jso.20782

Cohen, L., Warneke, C., Fouladi, R.T., Rodriguez, M.A., & Chaoul-Reich, A. (2004). Psychological adjustment and sleep quality in a randomized trial of the effects of a Tibetan yoga intervention in patients with lymphoma. *Cancer, 100,* 2253–2260.

Courneya, K.S. (2001). Exercise interventions during cancer treatment: Biopsychosocial outcomes. *Exercise and Sports Science Reviews, 29*(2), 60–64. doi:10.1097/00003677-200104000-00004

Courneya, K.S., Mackey, J.R., Bell, G.J., Jones, L.W., Field, C.J., & Fairey, A.S. (2003). Randomized controlled trial of exercise training in postmenopausal breast cancer survivors. *Journal of Clinical Oncology, 21,* 1660–1668. doi:10.1200/JCO.2003.04.093

Courneya, K.S., Segal, R.J., Mackey, J.R., Gelmon, K., Reid, R.D., Friedenreich, C.M., . . . McKenzie, D.C. (2007). Effects of aerobic and resistance exercise in breast cancer patients receiving adjuvant chemotherapy: A multicenter randomized controlled trial. *Journal of Clinical Oncology, 25,* 4396–4404.

Demark-Wahnefried, W., Peterson, B.L., Winer, E.P., Marks, L., Aziz, N., Marcom, P.K., . . . Rimer, B.K. (2001). Changes in weight, body composition, and factors influencing energy balance among premenopausal breast cancer patients receiving adjuvant chemotherapy. *Journal of Clinical Oncology, 19,* 2381–2389.

Duijts, S.F., Faber, M.M., Oldenburg, H.S., van Beurden, M., & Aaronson, N.K. (2011). Effectiveness of behavioral techniques and physical exercise on psychosocial functioning and health-related quality of life in breast cancer patients and survivors—A meta-analysis. *Psycho-Oncology, 20,* 115–126. doi:10.1002/pon.1728

Engel, J., Kerr, J., Schlesinger-Raab, A., Sauer, H., & Holzel, D. (2004). Quality of life following breast-conserving therapy or mastectomy: Results of a five-year prospective study. *Breast Journal, 10,* 223–231. doi:10.1111/j.1075-122X.2004.21323.x

Eton, D.T., Cella, D., Yost, K.J., Yount, S.E., Peterman, A.H., Neuberg, D.S., . . . Wood, W.C. (2004). A combination of distribution- and anchor-based approaches determined minimally important differences (MIDs) for four endpoints in a breast cancer scale. *Journal of Clinical Epidemiology, 57,* 898–910.

Eyigor, S., Karapolat, H., Yesil, H., Uslu, R., & Durmaz, B. (2010). Effects of Pilates exercises on functional capacity, flexibility, fatigue, depression, and quality of life in female breast cancer patients: A randomized controlled study. *European Journal of Physical Rehabilitation Medicine, 46,* 481–487.

Friedenreich, C.M., Gregory, J., Kopciuk, K.A., Mackey, J.R., & Courneya, K.S. (2009). Prospective cohort study of lifetime physical activity and breast cancer survival. *International Journal of Cancer, 124,* 1954–1962. doi:10.1002/ijc.24155

Galvao, D.A., & Newton, R.U. (2005). Review of exercise intervention studies in cancer patients. *Journal of Clinical Oncology, 23,* 899–909. doi:10.1200/jco.2005.06.085

Göltner, E., Fischbach, J.U., Mönter, B., Kraus, A., & Vorherr, H. (1985). Objective measurement of lymphoedema after mastectomy [in German]. *Deutsche Medizinische Wochenschrift, 110,* 949–952.

Holmes, M.D., Chen, W.Y., Feskanich, D., Kroenke, C.H., & Colditz, G.A. (2005). Physical activity and survival after breast cancer diagnosis. *JAMA, 293,* 2479–2486. doi:10.1001/jama.293.20.2479

Hutnick, N.A., Williams, N.I., Kraemer, W.J., Orsega-Smith, E., Dixon, R.H., Bleznak, A.D., & Mastro, A.M. (2005). Exercise and lymphocyte activation following chemotherapy for breast cancer. *Medicine and Science in Sports and Exercise, 37,* 1827–1835.

Irwin, M.L., Cadmus, L., Alvarez-Reeves, M., O'Neil, M., Mierzejewski, E., Latka, R., . . . Mayne, S.T. (2008). Recruiting and retaining breast cancer survivors into a randomized controlled exercise trial: The Yale Exercise and Survivorship Study. *Cancer, 112*(11, Suppl.), 2593–2606. doi:10.1002/cncr.23446

Irwin, M.L., McTiernan, A., Bernstein, L., Gilliland, F.D., Baumgartner, R., Baumgartner, K., & Ballard-Barbash, R. (2004). Physical activity levels among breast cancer survivors. *Medicine and Science in Sports and Exercise, 36,* 1484–1491.

Karki, A., Simonen, R., Malkia, E., & Selfe, J. (2005). Impairments, activity limitations, and participation restrictions 6 and 12 months after breast cancer operation. *Journal of Rehabilitation Medicine, 37*(3), 180–188. doi:10.1080/16501970410024181

Keays, K.S., Harris, S.R., Lucyshyn, J.M., & MacIntyre, D.L. (2008). Effects of Pilates exercises on shoulder range of motion, pain, mood, and upper-extremity function in women living with breast cancer: A pilot study. *Physical Therapy, 88,* 494–510.

Kloubec, J.A. (2010). Pilates for improvement of muscle endurance, flexibility, balance, and posture. *Journal of Strength and Conditioning Research, 24,* 661–667. doi:10.1519/JSC.0b013e3181c277a6

Knols, R., Aaronson, N.K., Uebelhart, D., Fransen, J., & Aufdemkampe, G. (2005). Physical exercise in cancer patients during and after medical treatment: A systematic review of randomized and controlled clinical trials. *Journal of Clinical Oncology, 23,* 3830–3842.

Kuchinski, A.M., Reading, M., & Lash, A.A. (2009). Treatment-related fatigue and exercise in patients with cancer: A systematic review. *Medsurg Nursing, 18*(3), 174–180.

Levine, B., Kaplanek, B., & Jaffe, W.L. (2009). Pilates training for use in rehabilitation after total hip and knee arthroplasty. *Clinical Orthopaedics and Related Research, 467,* 1468–1475.

Levine, B., Kaplanek, B., Scafura, D., & Jaffe, W.L. (2007). Rehabilitation after total hip and knee arthroplasty. *Bulletin of the NYU Hospital for Joint Disease, 65,* 120–125.

McCausland, L.L. (2010). Dragon boat racing: Life after breast cancer. *American Journal of Nursing, 110*(10), 48–54.

McNair, D.M., Lorr, M., & Droppleman, L.F. (1992). *EdITS manual for Profile of Mood States*. San Diego, CA: EITS.

McNeely, M.L., Campbell, K.L., Rowe, B.H., Klassen, T.P., Mackey, J.R., & Courneya, K.S. (2006). Effects of exercise on breast cancer patients and survivors: A systematic review and meta-analysis. *Canadian Medical Association Journal, 175*, 34–41.

Merrithew, M. (2009). Pilates for pain management. *Rehab Management, 22,* 24, 26–27.

Mock, V., Frangakis, C., Davidson, N.E., Ropka, M.E., Pickett, M., Poniatowski, B., . . . McCorkle, R. (2005). Exercise manages fatigue during breast cancer treatment: A randomized controlled trial. *Psycho-Oncology, 14,* 464–477. doi:10.1002/pon.863

Nesvold, I.L., Dahl, A.A., Lokkevik, E., Mengshoel, A.M., & Fossa, S.D. (2008). Arm and shoulder morbidity in breast cancer patients after breast-conserving therapy versus mastectomy. *Acta Oncologica, 47,* 835–842. doi:10.1080/02841860801961257

Norman, G.R., Sloan, J.A., & Wyrwich, K.W. (2003). Interpretation of changes in health-related quality of life: The remarkable universality of half a standard deviation. *Medical Care, 41,* 582–592.

Norman, S.A., Localio, A.R., Potashnik, S.L., Simoes Torpey, H.A., Kallan, M.J., Weber, A. L., . . . Solin, L.J. (2009). Lymphedema in breast cancer survivors: Incidence, degree, time course, treatment, and symptoms. *Journal of Clinical Oncology, 27,* 390–397.

Norman, S.A., Miller, L.T., Erikson, H.B., Norman, M.F., & McCorkle, R. (2001). Development and validation of a telephone questionnaire to characterize lymphedema in women treated for breast cancer. *Physical Therapy, 81,* 1192–1205.

Ohira, T., Schmitz, K.H., Ahmed, R.L., & Yee, D. (2006). Effects of weight training on quality of life in recent breast cancer survivors: The Weight Training for Breast Cancer Survivors (WTBS) study. *Cancer, 106,* 2076–2083. doi:10.1002/cncr.21829

Peters, T.M., Schatzkin, A., Gierach, G.L., Moore, S.C., Lacey, J.V., Jr., Wareham, N.J., . . . Leitzmann, M.F. (2009). Physical activity and postmenopausal breast cancer risk in the NIH-AARP diet and health study. *Cancer Epidemiology, Biomarkers and Prevention, 18,* 289–296. doi:10.1158/1055-9965.epi-08-0768

Pinto, B.M., Rabin, C., Papandonatos, G.D., Frierson, G.M., Trunzo, J.J., & Marcus, B.H. (2008). Maintenance of effects of a home-based physical activity program among breast cancer survivors. *Supportive Care in Cancer, 16,* 1279–1289.

Rietman, J.S., Dijkstra, P.U., Hoekstra, H.J., Eisma, W.H., Szabo, B.G., Groothoff, J.W., & Geertzen, J.H. (2003). Late morbidity after treatment of breast cancer in relation to daily activities and quality of life. *European Journal of Surgical Oncology, 29,* 229–238.

Rovell, D. (2010). Survey: Pilates exploding, darts and billiards plummeting. Retrieved from http://bit.ly/9oEJZD

Rydeard, R., Leger, A., & Smith, D. (2006). Pilates-based therapeutic exercise: Effect on subjects with nonspecific chronic low back pain and functional disability: A randomized controlled trial. *Journal Orthopaedic and Sports Physical Therapy, 36,* 472–484.

Schmitz, K.H. (2010). *The LIVESTRONG at the YMCA collaboration: Opportunities and challenges of exercise programs for cancer survivors at the Y.* Retrieved from http://bit.ly/wjscbG

Schmitz, K.H., Ahmed, R.L., Troxel, A., Cheville, A., Smith, R., Lewis-Grant, L., . . . Greene, Q.P. (2009). Weight lifting in women with breast cancer-related lymphedema. *New England Journal of Medicine, 361,* 664–673. doi:10.1056/NEJMoa0810118

Segal, R., Evans, W., Johnson, D., Smith, J., Colletta, S., Gayton, J., . . . Reid, R. (2001). Structured exercise improves physical functioning in women with stages I and II breast cancer: Results of a randomized controlled trial. *Journal of Clinical Oncology, 19,* 657–665.

Shand, D. (2004). Pilates to pit. *Lancet, 363,* 1340.

Siqueira Rodrigues, B.G., Ali Cader, S., Bento Torres, N.V., Oliveira, E.M., & Martin Dantas, E.H. (2010). Pilates method in personal autonomy, static balance, and quality of life of elderly females. *Journal of Bodywork and Movement Therapies, 14,* 195–202. doi:10.1016/j.jbmt.2009.12.005

Skrzypulec, V., Tobor, E., Drosdzol, A., & Nowosielski, K. (2009). Biopsychosocial functioning of women after mastectomy. *Journal of Clinical Nursing, 18,* 613–619.

Springer, B.A., Levy, E., McGarvey, C., Pfalzer, L.A., Stout, N.L., Gerber, L.H., . . . Danoff, J. (2010). Preoperative assessment enables early diagnosis and recovery of shoulder function in patients with breast cancer. *Breast Cancer Research and Treatment, 120,* 135–147.

Stanton, A.W., Northfield, J.W., Holroyd, B., Mortimer, P.S., & Levick, J.R. (1997). Validation of an optoelectronic limb volumeter (perometer). *Lymphology, 30,* 77–97.

Stevinson, C., Lawlor, D.A., & Fox, K.R. (2004). Exercise interventions for cancer patients: Systematic review of controlled trials. *Cancer Causes Control, 15,* 1035–1056.

Stout Gergich, N.L., Pfalzer, L.A., McGarvey, C., Springer, B., Gerber, L.H., & Soballe, P. (2008). Preoperative assessment enables the early diagnosis and successful treatment of lymphedema. *Cancer, 112,* 2809–2819. doi:10.1002/cncr.23494

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