Safety of Weightlifting Among Women with or at Risk for Breast Cancer–Related Lymphedema: Musculoskeletal Injuries and Health Care Use in a Weightlifting Rehabilitation Trial

JUSTIN C. BROWN, ANDREA B. TROXEL, KATHRYN H. SCHMITZ

Department of Biostatistics and Epidemiology and Center for Clinical Epidemiology and Biostatistics, Perelman School of Medicine, University of Pennsylvania, Philadelphia, Pennsylvania, USA

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LEARNING OBJECTIVES

After completing this course, the reader will be able to:

1. Elucidate the risk-to-benefit relationship of prescribing weightlifting to breast cancer survivors with or at risk for lymphedema.
2. Identify the frequency and describe common musculoskeletal injuries and health care needs of breast cancer survivors that may require dose modification or cessation of weightlifting exercise.
3. Identify the need for trained exercise professionals prepared with the knowledge and skills to encounter the musculoskeletal and health care needs of breast cancer survivors engaging in weightlifting exercise.

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ABSTRACT

Introduction. It has been noted that only 14% of all clinical trials are translated into practice. The objective of this paper is to promote translation of an efficacious rehabilitative exercise program for breast cancer survivors by clarifying for clinicians the safety profile of participants (e.g., rates of musculoskeletal injury and referral to medical professionals), and to use this evidence to make recommendations on the appropriate training of health and fitness staff who would be capable of safely, effectively, and sustainably delivering the program.

Methods. Breast cancer survivors with and at risk for lymphedema were randomized to twice-weekly weightlift-

ing or standard care for 1 year. An injury survey and health care evaluation were administered after 1 year and in 3-month intervals, respectively.

Results. The cumulative incidence and rate of injury were higher in the weightlifting than in the control group. The injury rates were 2.3 and 0.3 per 1,000 bouts of weightlifting among breast cancer survivors with and at risk for lymphedema, respectively. Among breast cancer survivors with or at risk for lymphedema, 20.9% in the weightlifting group had an encounter with a health care provider that required cessation or dose modification of weightlifting.

Correspondence: Kathryn H. Schmitz, Ph.D., M.P.H., University of Pennsylvania School of Medicine, 423 Guardian Drive, 8th Floor, Blockley Hall, Philadelphia, Pennsylvania 19104, USA. Telephone: 215-898-6604; Fax: 251-573-5311; e-mail: schmitz@mail.med.upenn.edu Received January 23, 2012; accepted for publication May 8, 2012; first published online in *The Oncologist Express* on July 2, 2012. ©AlphaMed Press 1083-7169/2012/\$20.00/0 <http://dx.doi.org/10.1634/theoncologist.2012-0035>

Conclusion. Despite the demonstrated efficacy of weightlifting, musculoskeletal injuries and other health problems did occur. Therefore, for the successful translation of this rehabilitative intervention into clinical practice, health and

fitness professionals working with breast cancer survivors need the knowledge, skills, and abilities that clarify their scope of practice to address these health care needs. *The Oncologist* 2012;17:1120–1128

INTRODUCTION

There are over two million breast cancer survivors living in the U.S. [1]. A major concern that affects 6%–70% of breast cancer survivors is lymphedema [2, 3]. Lymphedema is an accumulation of protein-rich fluid in the upper limbs and torso, resulting in limb swelling, discomfort, and, in some cases, altered physical function [4]. Lymphedema occurs from damage to the lymphatic system, such as sentinel-node biopsy, complete axillary dissection, and radiation-induced fibrosis [4].

Previous recommendations to reduce the risk for lymphedema onset include limiting the use of the affected arm in activities of daily living to prevent excess demand on the affected arm [5]. However, an efficacious rehabilitative exercise intervention was published in the past few years that challenges these recommendations. The Physical Activity and Lymphedema (PAL) trial intervention showed that breast cancer survivors with lymphedema who engage in weightlifting reduce their need for lymphedema treatment by 50% versus standard care [6]. Furthermore, breast cancer survivors at risk for lymphedema with five or more lymph nodes removed who engaged in the PAL weightlifting intervention experienced a 70% lower risk in the likelihood of arm swelling than with standard care over the 1-year study [7]. This evidence is consistent with the hypothesis that slowly progressive increases in the ability of the affected limb to do physiologic work are better than the progressive deconditioning that results with limiting use of the affected limb [8].

Translation of efficacious interventions into clinical practice is complicated and there are a myriad of reasons why only 14% of all clinical trials are implemented into clinical practice [9]. In the case of an efficacious rehabilitative exercise intervention for breast cancer survivors, the ability of clinicians to refer breast cancer survivors into a rehabilitative exercise program that is both safe and efficacious requires understanding of both the benefits and the risks posed by the intervention and the level of training of health-fitness professionals required to ensure that both safety and efficacy are maintained. To this end, the purpose of this secondary analysis of the PAL trial was threefold. First, we sought to quantify and compare the incidence of musculoskeletal injury in a large cohort of breast cancer survivors with or at risk for developing breast cancer–related lymphedema (BCRL) randomized to twice-weekly weightlifting or standard care for 1 year. Second, given that there is always a risk for injury or adverse effects in any exercise intervention [10], we sought to put the risks for breast cancer survivors in context by comparing them with the risks for musculoskeletal injury among women without a history of cancer engaging in a similar weightlifting protocol [11]. Finally, we sought to identify the frequency of health care use that may require dose modification of weightlifting or medical referral.

METHODS

Design

The PAL trial was a randomized controlled trial of 295 breast cancer survivors whose primary aim was to assess differences in lymphedema outcomes resulting from twice-weekly progressive weightlifting in breast cancer survivors with or at risk for developing BCRL, compared with standard care [12]. The primary outcomes of this study are published elsewhere [6, 7]. The goal of this clinical epidemiologic paper is to provide information beyond what was presented in the primary outcomes publications, toward the goal of promoting translation of this efficacious intervention into clinical practice.

Sample

The trial included breast cancer survivors with BCRL ($n = 141$) or at risk for developing BCRL ($n = 154$). Detailed inclusion criteria for participation are elsewhere [12]. In brief, participation criteria included the following: (a) female breast cancer survivor 1–15 years postdiagnosis, among those with lymphedema, and 1–5 years postdiagnosis, among those at risk for developing lymphedema; (b) freedom from cancer at study entry; (c) one or more lymph node removed; and (d) no medical conditions or contraindicated medications that would prohibit participation in an exercise program. Additional criteria included: (e) a body mass index ≤ 50 kg/m², (f) no plans for surgery during the intervention period, (g) no history of bilateral lymph node dissection, (h) no weightlifting in the previous 1 year, and (i) weight stable and not attempting to lose weight. Randomization of participants was conducted using minimization via computer software.

Informed Consent

The University of Pennsylvania institutional review board approved the study protocol, and study staff obtained informed consent from all study participants. Pertinent to this secondary analysis, the informed consent document stated that there was a small risk for muscle injury from the weightlifting program. Participants were also informed that these muscular injuries may take several months to heal and may limit usual daily activities for a period of days or weeks. Participants were informed that they or their health insurance would be billed for the costs of medical care during the study. An exception to medical care billing was for the costs of care for lymphedema flare-ups or the onset of lymphedema, which was paid for by the study.

Measures

Measurements were completed at baseline and at 3-month intervals up to 1 year postrandomization [12]. Demographic characteristics were obtained by self-report. Cancer staging

was taken from state cancer registries, surgical pathology reports, and self-report. Treatment history was self-reported. The number of lymph nodes removed was obtained from surgical pathology. Anthropometry measures included height, weight, and whole-body dual-energy x-ray absorptiometry scan (Hologic Discovery, Bedford, MA). Physical activity was assessed using the International Physical Activity Questionnaire [13]. Strength measurements were collected at baseline and 12 months by one-repetition maximum testing on bench press and leg press exercises [14]. Adherence to the weightlifting protocol was obtained with intervention staff review of standardized weightlifting logs [12].

Musculoskeletal Injury Assessment

A survey assessed self-reported musculoskeletal injury over the 1-year study period. The content of the musculoskeletal injury questionnaire was modeled after the adverse event reporting guidelines developed by the National Institutes of Health [15], an approach implemented by Warren and Schmitz [16]. The musculoskeletal injury survey asked questions related to the incidence of injury over the previous 1 year, type of injury (joint or soft tissue), anatomic location of the injury, relatedness to weightlifting, severity of injury, and duration of injury as it impaired activities of daily living [15]. The numerator was self-reported injury. Herein, a musculoskeletal injury is any injury relating to weightlifting that impaired activities of daily living for ≥ 1 week. The definition of musculoskeletal was selected to reflect prior definitions of musculoskeletal injury and to facilitate direct comparisons of rates of injury among breast cancer survivors and women without a history of cancer [11, 16]. Two denominators were used to calculate the rate of musculoskeletal injury: denominator 1, self-reported bouts of physical activity; denominator 2, number of weightlifting bouts completed in 1 year. The number of self-reported bouts of physical activity was a denominator measure in both the weightlifting and control groups. The number of self-reported weightlifting sessions was a denominator measure in the weightlifting group only because the control group abstained from weightlifting activities during the intervention.

Health Care Use Assessment

We administered a health care use evaluation to all study participants at baseline and at 3-month intervals over the 1-year intervention period. We asked if the participant had seen a health care professional (including physical therapist) for any symptoms or health issues in the previous period. Answers encompassed any health care treatment received, including but not limited to treatment needed as a result of weightlifting or lymphedema care.

Intervention

All participants, regardless of treatment group or control group assignment, were required to attend a 1-hour educational lecture entitled the "lymphedema education session," which was based on material from the National Lymphedema Network [17–20]. For the first 3 months of weightlifting, women received twice-weekly, group-based, supervised instruction on the proper biome-

chanics and safety of weightlifting by certified health-fitness professionals employed in community fitness centers. Prior to the intervention, all health-fitness professionals received a 3-day training session from the study investigator (K.H.S.) reviewing the exercises, proper biomechanics, and signs and symptoms of lymphedema [12]. Breast cancer survivors with lymphedema underwent a preparticipation physical therapy evaluation; breast cancer survivors at risk for lymphedema underwent a preparticipation evaluation by a certified health-fitness professional. The preparticipation evaluation included the following: handgrip dynamometer strength testing, nine-hole peg test, and visual inspection for asymmetry, color, edema, and tissue texture of the affected and unaffected arms [12]. The preparticipation evaluation also included an examination of range of motion in the shoulder and cervical spine and special tests to examine shoulder, rotator cuff, and spinal stenosis pathologies. During the preparticipation evaluation, lymphedema was measured using bioimpedance, circumferences, water displacement volumetry, and the Norman Lymphedema survey [12, 21, 22].

Weightlifting sessions lasted ~90 minutes and included upper and lower body exercises. Participants started with two sets of 10 repetitions of each exercise and increased to three sets of 10 repetitions over 5 weeks. Prior to each weightlifting session, all participants engaged in at least 10 minutes of aerobic activity (usually treadmill walking), static stretching of the upper and lower body, and abdominal strengthening exercises [6, 7, 12]. The weightlifting exercises included the seated row, chest press, lateral or front raise, bicep curl, triceps pushdown, leg press, back extension, leg extension, and leg curl. At the end of each exercise session, participants also engaged in static stretching, to reduce the likelihood for muscular soreness. For each exercise, if there were no changes in arm symptoms after two exercise sessions at a given weight, the load was increased by the smallest possible increment (typically 1 pound). All weightlifting exercises were symptom limited, such that if a participant reported pain or discomfort with a specific exercise, that exercise was modified or substituted appropriately by the health-fitness professional (e.g., straight leg lifts were substituted for those with knee pain while doing leg extensions until the knee pain resolved). There was no upper limit on the maximal weight lifted over 1 year. After 3 months of supervised weightlifting, participants continued unsupervised twice-weekly weightlifting for 9 months. For the duration of the 1-year study, health-fitness professionals asked about changes in lymphedema symptoms weekly and assessed arm volume monthly. All participants with lymphedema, and those who developed lymphedema, were required to wear a custom-fitted compression garment during weightlifting activities. If a participant with lymphedema arrived to exercise without her compression garment, she was asked to do all the exercises except for the upper body weightlifting for that session.

Analysis

Continuous variables are summarized with means and standard deviations (or medians where noted). Categorical variables are summarized with rates and percentages. Baseline characteristics and change variables were assessed using the Wilcoxon rank-sum test for continuous variables and Fisher's

exact test for categorical variables, with a two-sided statistical significance established at $p < .05$.

Incidence risk and rates with 95% confidence intervals (CIs) using the two different denominators described previously were calculated for each definition of injury. Logistic regression estimated the odds ratio (OR) and 95% CI of injury between the weightlifting and control groups for each definition of injury using the Yates' continuity correction to test for statistically significant differences between treatment groups [23]. Variables analyzed as potential covariates included the baseline characteristics shown in Tables 1 and 2. None of these covariates influenced the rates of weightlifting-related musculoskeletal injury; therefore, all models are unadjusted. The software package Stata 11.1 (StataCorp LP, College Station, TX) was used for all statistical analyses. A sensitivity analysis of musculoskeletal injury rates was conducted using multiple imputation and then using simple imputation assuming that those lost to follow-up did or did not experience a musculoskeletal injury. The rates of injury did not differ substantively between methods. Herein, all analyses presented are among participants who completed the intervention.

RESULTS

Among 295 breast cancer survivors with or at risk for lymphedema, 147 were randomized to weightlifting. After the 1-year intervention, 243 breast cancer survivors completed the study. Attrition rates did not differ between lymphedema diagnoses or randomization groups (results not shown). The baseline characteristics were similar between groups with the exception of tamoxifen use among breast cancer survivors with lymphedema ($p = .008$) (Table 1). Muscular strength among breast cancer survivors with and at risk for lymphedema was better in the weightlifting group than with standard care over the 1-year intervention (Table 2). Breast cancer survivors at risk for lymphedema in the weightlifting group had less body fat than those in the control group at 12 months ($p = .03$). All other anthropometric and physical activity variables between the weightlifting and control groups in both breast cancer survivors with and at risk for lymphedema did not differ.

Cumulative Incidence of Weightlifting-Related Musculoskeletal Injuries

Over the 1-year intervention, nine breast cancer survivors reported 10 musculoskeletal injuries related to weightlifting that impaired activities of daily living for ≥ 1 week (all in the weightlifting group). There were eight and two musculoskeletal injuries reported among breast cancer survivors with and at risk for lymphedema, respectively. The cumulative incidence of musculoskeletal injury in the weightlifting group among breast cancer survivors with lymphedema was 10.2 (95% CI, 9.4–11.1), and among breast cancer survivors at-risk for lymphedema this was 3.4 (95% CI, 2.9–3.9) per 100 breast cancer survivors.

Rates of Musculoskeletal Injury

Musculoskeletal injury rates varied by lymphedema diagnosis, group assignment, and choice of denominator (Table 3). Rates

of musculoskeletal injury were similar to those apparently healthy women engaging in a comparable weightlifting protocol (Table 3) [16].

Odds for Musculoskeletal Injury

Breast cancer survivors with lymphedema in the weightlifting group had a greater odds of experiencing a musculoskeletal injury than those in the control group (OR, 19.9; 95% CI, 5.1–77.1; $p = .001$). Breast cancer survivors at risk for lymphedema in the weightlifting group did not have a higher risk for musculoskeletal injury (OR, 5.6; 95% CI, 0.31–26.1; $p = .440$).

Musculoskeletal Injury Profile

Breast cancer survivors experienced both upper body and lower body injuries resulting from weightlifting. Injuries occurring from weightlifting varied in severity, occurrence, and outcome by the end of the study (Table 4). No breast cancer survivor in the PAL trial reported an unexpected or life-threatening injury associated with weightlifting that required reporting to the data safety monitoring board or institutional review board at the University of Pennsylvania.

Specific Exercises Associated with Injury

During the first 3 months of the exercise intervention, the health-fitness professionals noted that participants had particular difficulty and reported shoulder discomfort with machine-based lateral raises. We subsequently modified this exercise to a shoulder scaption movement or front raises with light dumbbells. Shoulder scaption and front raises were less difficult and participants reported less discomfort than with machine-based lateral raises. An additional exercise was the one-arm dumbbell row exercise, which was replaced by a machine-based seated row. Lastly, the commonly observed damage to the long nerve that innervates the serratus anterior among breast cancer survivors resulted in some difficulty getting women to use proper biomechanical form for the dumbbell chest press exercise. If a participant was unable to demonstrate good biomechanical form for the dumbbell chest press exercise by the end of supervised exercise, she was taught how to use the chest press machine available in the facility where she was engaging in weightlifting.

Health Care Use Rates

Over 3,129 person-months of follow-up, 108 women reported a health issue (36.6% of the total cohort), many of which resolved in < 1 week. We referred 69 women (23.4% of the total cohort) for medical evaluation when they reported a change in symptoms lasting ≥ 1 week. Among breast cancer survivors in the weightlifting group, 68 women reported a health issue (45.9% of the weightlifting group), many of which resolved in < 1 week. Of these, we referred 31 women for medical evaluation (20.9% of the weightlifting group). In addition to musculoskeletal injury and lymphedema-related events [6, 7], breast cancer survivors in the weightlifting group experienced health issues that required dose modification or cessation of weightlifting exercise. These health issues most commonly included transient back ($n = 2$), shoulder ($n = 4$), and knee ($n = 4$) pain. Women also reported arthritic and neuropathic symp-

Table 1. Baseline characteristics by lymphedema diagnosis and study group

Variable	With lymphedema			At risk for lymphedema		
	Weightlifting	Control	<i>p</i> -value	Weightlifting	Control	<i>p</i> -value
Age, yrs	56 ± 9	57 ± 10	.57	54 ± 8	56 ± 8	.36
Education			.80			.51
High school or less	13 (18)	16 (23)		7 (9)	11 (14)	
Some college	26 (37)	24 (34)		28 (36)	23 (30)	
Beyond college	32 (45)	30 (43)		42 (55)	43 (56)	
Race/ethnicity			.87			.04
White	42 (60)	40 (56)		50 (65)	59 (76)	
Black	26 (37)	28 (39)		19 (25)	17 (22)	
Other ^a	2 (4)	2 (3)		8 (10)	1 (<1)	
Occupation			.15			.95
Professional	29 (41)	23 (33)		32 (42)	34 (44)	
Clerical or service	10 (14)	11 (16)		18 (23)	16 (21)	
Homemaker, student, or unemployed	8 (11)	4 (6)		6 (8)	8 (10)	
Other or unknown	9 (13)	4 (6)		8 (10)	6 (8)	
Retired	15 (21)	28 (40)		39 (15)	13 (17)	
Mos since cancer diagnosis	79 ± 45	88 ± 45	.23	39 ± 15	42 ± 16	.26
Cancer stage			.19			.34
1	33 (46)	24 (34)		44 (57)	43 (56)	
2	1 (1)	0		8 (10)	6 (8)	
3	22 (31)	22 (31)		25 (33)	28 (36)	
Unknown	15 (21)	24 (34)				
<i>n</i> of nodes removed	15 ± 8	16 ± 8	.59	8 ± 6	9 ± 6	.50
Chemotherapy, %	83	80	.67	73	69	.72
Radiation, %	83	76	.30	77	75	.99
Current receipt of drugs, %						
Tamoxifen	20	4	.008	21	19	.99
Aromatase inhibitors	0	1	.50	0	1	.99

Data are presented as *n* (%) unless otherwise specified (plus/minus values are mean ± standard deviation).

Percentages may not sum to 100 because of rounding error.

Data were analyzed using the Wilcoxon rank-sum test for continuous variables and Fisher's exact test for categorical variables.

^aIncludes American Indian or Alaskan Native, Asian, Hispanic, Latino, Portuguese or Cape Verdean, Native Hawaiian or other Pacific Islander.

toms of the hands (*n* = 2), and two women reported bacterial infections with exposures reportedly occurring in the locker rooms of exercise facilities.

DISCUSSION

Among breast cancer survivors at risk for lymphedema, the number of musculoskeletal injuries per 1,000 weightlifting sessions was *less than* that of women without a history of cancer. Among breast cancer survivors with lymphedema, the number of musculoskeletal injuries per 1,000 weightlifting sessions was similar to that of women without a history of cancer. Among all breast cancer survivors with and at risk for lymphedema, the anatomic locations of the musculoskeletal

injuries occurring as a result of weightlifting were similar to those of women without a history of cancer [16]. When combining the frequency of musculoskeletal injury, lymphedema exacerbation [6, 7], and other health care events associated with cancer survivorship requiring medical attention (described above), the number of events involved 20.9% of women in the weightlifting group. The frequent health care use of breast cancer survivors—directly and indirectly related to weightlifting—underscores the recommendation to establish a relationship between medical care providers and health-fitness professionals when delivering this weightlifting program. It is imperative that health-fitness professionals be equipped with the knowledge, skills, and abilities necessary to encounter ex-

Table 2. Strength, anthropometric variables, and physical activity at baseline and 12 months by lymphedema diagnosis and study group

Variable	Baseline			12 mos		
	Weightlifting	Control	<i>p</i> -value	Weightlifting	Control	<i>p</i> -value
Patients with lymphedema						
Bench press, maximum, lbs	43 ± 16	39 ± 13	.21	53 ± 18	39 ± 12	<.001
Leg press, maximum, lbs	182 ± 64	162 ± 58	.09	232 ± 66	165 ± 57	<.001
Weight, kg	82.4 ± 16.6	79.4 ± 17.6	.18	80.0 ± 15.6	79.0 ± 16.9	.66
BMI ^a	31.0 ± 6.2	29.9 ± 6.6	.21	30.0 ± 5.7	29.9 ± 6.5	.70
Body fat, %	40.1 ± 5.7	39.5 ± 5.2	.42	39.6 ± 6.3	39.9 ± 5.3	.90
Physical activity level, MET, minutes per wk, median (IQR)	2,549 (1,320–4,624)	2,217 (813–4,995)	.42	2,457 (1,146–5,517)	1,511 (594–3,954)	.10
<i>n</i> of bouts physical activity per week ^b	9.8 ± 5.9	9.7 ± 6.5	.74	9.7 ± 6.2	7.9 ± 6.2	.08
Patients at risk for lymphedema						
Bench press, maximum, lbs	41 ± 13	41 ± 13	.93	54 ± 12	43 ± 11	<.001
Leg press, maximum, lbs	170 ± 48	181 ± 54	.23	213 ± 50	192 ± 53	.02
Weight, kg	73.9 ± 5.1	76.8 ± 17.2	.27	72.4 ± 14.9	75.5 ± 17.1	.27
BMI ^a	27.5 ± 5.1	28.6 ± 6.2	.26	26.9 ± 5.0	28.0 ± 6.0	.25
Body fat, %	37.7 ± 5.6	39.3 ± 6.4	.11	37.3 ± 5.4	39.6 ± 6.5	.03
Physical activity level, MET, minutes per wk, median (IQR)	2,634 (1,536–4,644)	2,209 (839–5,103)	.31	4,227 (1,386–6,657)	3,132 (1,231–5,723)	.31
<i>n</i> of bouts physical activity per week ^b	10.2 ± 6.2	9.4 ± 6.8	.34	10.7 ± 6.4	10.6 ± 7.8	.35
Data are presented as mean ± standard deviation unless otherwise specified.						
Data were analyzed using the Wilcoxon rank-sum test for continuous variables and Fisher's exact test for categorical variables.						
<i>p</i> -values compare weightlifting with control within the timepoint (baseline or 12 months), respectively.						
^a BMI was calculated as the weight in kilograms divided by the square of the height in meters.						
^b Includes moderate and vigorous intensity physical activities.						
Abbreviations: BMI, body mass index; IQR, interquartile range; MET, metabolic equivalent.						

ercise-, disease-, and treatment-related health events, possessing the ability to modify the dose or terminate the exercise and providing medical referrals to a health care provider for medical management and follow-up, if appropriate.

A criticism encountered in exercise and cancer survivorship research is that interventions have not always collected systematic, unbiased data regarding the musculoskeletal injuries incurred resulting from the exercise intervention [24]. To our knowledge, one prior study has collected and reported systematic data among all cancer survivors participating in an exercise trial [25]. Jones conducted a systematic review examining the risks of exercise testing and exercise training among 118 exercise or physical activity studies among cancer survivors [24]. Only 16 of the 118 studies (13.5%) reported an adverse event occurring during exercise testing or exercise

training. Interestingly, only one study reported musculoskeletal injury—a foot fracture—during exercise training. Jones [24] suggested that the magnitude of underreporting of adverse events in exercise studies is a result, in part, of limited agreement on what constitutes an injury and inadequate methodology in assessing and reporting injuries and adverse events. Consistent with reports in the literature, published reports on the primary outcomes from the PAL trial did not mention any serious or unexpected adverse events [6, 7]. However, advocating the integration of any exercise program into the standard of care for cancer rehabilitation requires the implementation of systematic methods to assess injury or adverse effects resulting from the intervention among *all* study participants. This systematic data will provide evidence to improve intervention efficacy, patient safety, and subsequent program sustainability.

Table 3. Musculoskeletal injury rates by lymphedema diagnosis and study group

	Physical activity injury rate per 1,000 self-reported exercise bouts ^a		Weightlifting injury rate per 1,000 weightlifting sessions ^b	
	Weightlifting	Control	Weightlifting	Control
With lymphedema				
Weightlifting-related injury lasting ≥ 1 wk	0.4 (0.3–0.7)	0.0 (0.0–0.1)	2.3 (2.0–2.6)	–
At risk for lymphedema				
Weightlifting-related injury lasting ≥ 1 week	0.7 (0.4–1.0)	0.0 (0.0–0.1)	0.3 (0.2–0.5)	–
Women without a history of cancer ^c				
Weightlifting-related injury lasting ≥ 1 wk	Not reported	Not reported	2.6 (1.5–3.6)	–

^aNumerator = *n* of injuries; denominator = *n* of self-reported exercise bouts.
^bNumerator = *n* of injuries; denominator = *n* of weightlifting sessions completed.
^cFrom Warren M, Schmitz KH. Safety of strength training in premenopausal women: Musculoskeletal injuries from a two-year randomized trial. *Am J Health Promot* 2009;23:309–314.

Table 4. Profile of musculoskeletal injuries occurring with weightlifting (weightlifting group only)

With lymphedema (<i>n</i> = 59)–8 injuries				At risk for lymphedema (<i>n</i> = 59)–2 injuries			
Location	Occurrence	Severity ^a	Outcome ^b	Location	Occurrence	Severity ^a	Outcome ^b
Upper body injury				Upper body injury			
Shoulder	One time	Moderate	Healed, resolved	Shoulder	Ongoing	Severe	Present, receiving treatment
Shoulder	Transient	Severe	Healed, resolved	Wrist	One-time	Moderate	Healed, resolved
Shoulder	Ongoing	Moderate	Present, receiving treatment	–	–	–	–
Shoulder ^c	Ongoing	Severe	Present, receiving treatment	–	–	–	–
Shoulder	Ongoing	Severe	Present, receiving treatment	–	–	–	–
Lower body injury				Lower body injury			
Hip ^c	Transient	Moderate	Present, receiving treatment	–	–	–	–
Knee	Ongoing	Moderate	Present, receiving treatment	–	–	–	–
Knee	Transient	Severe	Present, receiving treatment	–	–	–	–

^aModerate, daily activities modified for ≥ 1 week; severe, daily activities stopped for ≥ 1 week.
^bOutcome was defined as the current status of the injury at the end of the intervention.
Present, receiving treatment: the symptom existed at the end of the study and the participant was currently receiving treatment specific to the musculoskeletal injury.
^cSame participant.

The PAL trial integrated multiple components to reduce the likelihood for lymphedema exacerbation and musculoskeletal injury. These components included a 1-hour educational lecture on lymphedema and a preparticipation evaluation that included objective and self-reported assessments of lymphedema, as well as exercise session characteristics de-

signed to reduce adverse effects (e.g., a warm up prior to weightlifting, supervised exercise to reinforce proper biomechanics, slow symptom-limited progression of weightlifting volume, and static stretching before and after weightlifting).

Despite a randomized controlled trial design, participants in the PAL trial were volunteers. It is possible that the volunteers in

our study are not representative of the general population of breast cancer survivors. Although similar with respect to demographic and clinical variables, they may have differed with respect to psychological readiness for weightlifting exercise. A strength and limitation of this study is the injury questionnaire. The strength arises from having administered the questionnaire to all participants, regardless of randomization, outcome, or intervention adherence. The limitation arises from the timing of administration: the survey was self-reported at the end of 1 year. Participants had to recall any injuries experienced over that time, leading to potential recall bias and missing the less severe injuries such as those experienced when beginning an exercise program [10]. Because of the self-reported nature of our survey, we were unable to obtain further information on the nature of each of these injuries, such as the specific diagnosis and if musculoskeletal imaging was performed.

Translation and Implication to Practice

Post-treatment cancer care has become very complex. This complexity has resulted in a variety of health care providers delivering information to prepare cancer patients for long-term survivorship. To incorporate exercise rehabilitation into cancer survivorship care, there is a need to inform patients and health care providers of the risks *and* benefits associated with exercise, and to provide clinicians and staff with streamlined resources to promote the integration of physical rehabilitation into the supportive care paradigm. The optimal point along the trajectory of cancer survivorship at which to advocate the use of exercise rehabilitation remains to be elucidated. The infrastructural issues associated with making rehabilitative exercise programming standard of care after breast cancer treatment also remains to be addressed.

Acknowledging the likelihood that musculoskeletal injury, lymphedema-related events, and other health care needs do arise during 1 year of weightlifting, health-fitness professionals who guide breast cancer survivors in exercise need training to respond appropriately. Health-fitness professionals must possess the broad knowledge to create and to modify an exercise program based on the specific needs of each participant. For the PAL trial, the principal investigator developed and delivered a 3-day (24-hour) training course to all 17 health-fitness professionals who worked with the participants and checked in with those health-fitness professionals weekly during the supervised intervention and monthly during the unsupervised weightlifting to troubleshoot any issues or challenges that arose.

Other key aspects of the PAL trial intervention experience that are central to translation into clinical practice include: (a) the preparticipation evaluations by research measurement staff for all participants and also by physical therapists for those with a prior diagnosis of lymphedema, (b) the patient education session that ensured that all 295 participants in the trial (treatment and control group) entered the study with a level playing field regarding their knowledge of lymphedema risk reduction guidelines, (c) systematic and ongoing surveillance by health-fitness professionals and research measurement staff for changes in objective measures or new symptoms that sug-

gested the need for an evaluation by a health care professional, (d) staff to whom the health-fitness professionals could turn to assist with getting the participants access to evaluations by health care professionals, (e) provision of lymphedema compression garments to ensure that all women with lymphedema exercised with appropriate compression, and (f) periodic review of musculoskeletal injury and lymphedema event rates by the PAL trial safety monitoring team. Those intending to implement an upper body weightlifting program for breast cancer survivors should consider these infrastructural aspects central to ensuring the safety and efficacy of their program.

The PAL trial prescribed a standard recommendation of weightlifting exercises; however, those recommended exercises were modified based on the best interests of each participant. An exercise not prescribed in the PAL trial that warrants future investigation is a rotator cuff strengthening exercise. A prior review hypothesized that breast cancer survivors may have an elevated risk for developing symptomatic rotator cuff impairments [26]. Strengthening the rotator cuff through weightlifting exercise may be an effective means to reduce shoulder impairment in the population of breast cancer survivors; however, this hypothesis has yet to be tested empirically.

The nature of weightlifting among breast cancer survivors supports the need for interdisciplinary collaboration and communication among medical care providers and health-fitness professionals—all striving to provide efficacious and accessible interventions to improve quality of life, without compromising patient safety. The risks of continued deconditioning must also be weighed against the risks of weightlifting in breast cancer survivors; efforts to ensure safety should be handled in a manner that does not create barriers to exercise.

To this end, clinicians should refer breast cancer survivors to physical therapists with specific training in oncology or highly trained health-fitness professionals, such as those who are American College of Sports Medicine–certified cancer exercise specialists, to provide counsel for those interested in weightlifting [27]. Topics addressed should include proper biomechanics and progression of exercise, self-monitoring of signs and symptoms of lymphedema and musculoskeletal injury, and appropriate contact information if questions or concerns arise. Tailoring this curriculum to each participant and highlighting issues pertinent to her unique health history are ideal. Another consideration is the use of preparticipation evaluations among breast cancer survivors. It is unknown if eliminating the preparticipation evaluation would reduce barriers to exercise without compromising participant safety. We do acknowledge that obtaining a preparticipation evaluation may be an unrealistic recommendation for the 2.6 million breast cancer survivors in the U.S., given the possibility for geographical and financial constraints prohibiting such an evaluation. Yet, the body of evidence suggests that exercise is a potent rehabilitative modality among cancer survivors; therefore a research priority is warranted to elucidate the optimal balance to reduce barriers to exercise while promoting safety among cancer survivors. To this end, future research recommendations include the development and implementation of cost-effective training programs to educate health-fitness pro-

professionals with the knowledge, skills, and abilities necessary to conduct preparticipation evaluations and safely prescribe exercise.

CONCLUSION

In conclusion, this study provides evidence of injuries occurring resulting from weightlifting and profiles the health care use occurring among breast cancer survivors. The risk-to-benefit ratio of weightlifting among breast cancer survivors has emerged to be more complex than prior reports may suggest. This complexity warrants adequate education of breast cancer survivors engaging in weightlifting, as well as training of the health-fitness professionals who prescribe this rehabilitative modality. Translating the use of weightlifting to the 2.6 million breast cancer survivors in the U.S. warrants an infrastructure similar in rigor to that of cardiac rehabilitation, im-

plementing the use of trained cardiac rehabilitation specialists and a core of educational goals satisfactory for cardiac rehabilitation [28].

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AUTHOR CONTRIBUTIONS

Conception/Design: Justin C. Brown, Andrea B. Troxel, Kathryn H. Schmitz
Provision of study material or patients: Kathryn H. Schmitz
Collection and/or assembly of data: Justin C. Brown, Andrea B. Troxel, Kathryn H. Schmitz
Data analysis and interpretation: Justin C. Brown, Andrea B. Troxel, Kathryn H. Schmitz
Manuscript writing: Justin C. Brown, Andrea B. Troxel, Kathryn H. Schmitz
Final approval of manuscript: Justin C. Brown, Andrea B. Troxel, Kathryn H. Schmitz

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