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Proactive Approach to Lymphedema Risk Reduction: A Prospective Study

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Abstract

Background—Advances in cancer treatments continue to reduce the incidence of lymphedema. Yet, many breast cancer survivors still face long-term post-operative challenges as a result of developing lymphedema. The purpose of this study was to preliminarily evaluate *The-Optimal-Lymph-Flow* program, a patient-centered education and behavioral program focusing on self-care strategies to enhance lymphedema risk reduction by promoting lymph flow and optimize body mass index.

Methods—A prospective, longitudinal, quasi-experimental design with repeated-measures was used. The study outcomes included lymph volume changes by *infra-red perometer* and body mass index by a *bioimpedance* device at pre-surgery baseline, 2-4 weeks after surgery, 6-month, and 12-month follow-up. A total of 140 patients were recruited and participated in *The-Optimal-Lymph-Flow* program; 134 patients completed the study with 4% attrition rate.

Results—Fifty-eight percent patients had axillary node dissection and 42% had sentinel lymph node biopsy. The majority (97%) of patients maintained and improved their preoperative limb volume and body mass index at the study endpoint of 12 months following cancer surgery. Cumulatively, 2 patients with sentinel lymph node biopsy and 2 patients with the axillary lymph node dissection had measurable lymphedema (>10% limb volume change). At 12-month follow-up, among the 4 patients with measurable lymphedema, 2 patients' limb volume returned to pre-operative level without compression therapy but by maintaining *The-Optimal-Lymph-Flow* exercises to promote daily lymph flow.

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Conclusions—This educational and behavioral program is effective to enhance lymphedema risk reduction. The study provided initial evidence for emerging change in lymphedema care from treatment-focus to proactive risk reduction.

Keywords

Lymphedema; Breast Cancer; Risk Reduction

Introduction

Lymphedema is one of the unfortunate outcomes of breast cancer treatment since it negatively impacts survivors' overall quality of life [1-3]. Breast cancer-related lymphedema is characterized by an accumulation of lymph fluid in the interstitial spaces of the affected limb, leading to chronic ipsilateral limb swelling coupled with multiple distressing symptoms [3-5]. Breast cancer survivors who undergo breast surgery, dissection of lymph nodes and vessels, and radiation are known to have a compromised lymphatic system, leading to ineffective lymphatic drainage, thus risk for lymphedema [6-7]. In addition to the risk factor of compromised lymphatic drainage from cancer treatment, higher body mass index (BMI) is also an established risk factor for lymphedema [8-11]. Physiologically, a larger body mass creates a disproportion in lymph transport and capacity, resulting in excess extracellular fluid [12]. Women are 1.11 times more at risk for developing lymphedema with every increase of 1kg/m^2 in their BMI [8-11].

Patient education focusing on risk reduction strategies holds great promise for reducing the risk of lymphedema [13]. Research evidence demonstrates that patient education remains an important predictor of lymphedema outcome after controlling for confounding cancer treatment-related risk factors [13]. Risk factors, such as compromised lymphatic drainage and higher BMI, may be modified through self-care strategies. Current patient education emphasizes precautionary lifestyle behaviors, such as avoidance of repetitive limb movement, lifting weighted objects, needle punctures, blood draw, and the use of compression garments for air travel in the affected limb [14-15]. To date, there is a paucity of high quality evidence to support these practices that reduce the risk of lymphedema [14-15]. One early study showed a significant decrease in limb volume (LV) using the compression garments for patients with $>3\%$ LV increase over a 4-week short duration [16]. Research is lacking to provide evidence to reduce the risk or halt the progression of lymphedema through self-care strategies targeting risk factors of compromised lymphatic drainage and higher BMI. To address this important clinical need, we conducted a pilot study to preliminarily evaluate a patient-centered educational and behavioral lymphedema risk reduction program (*The-Optimal-Lymph-Flow*) focusing on promoting lymph flow and optimizing BMI over a 12-month period after cancer surgery.

Methods

Study Design

A prospective, longitudinal, quasi-experimental design with repeated-measures was used to: (1) Evaluate the safety, feasibility, and acceptability of *The-Optimal-Lymph-Flow* program;

and (2) Preliminarily evaluate the efficacy of the program, specifically limb volume (LV) change and BMI. The study was approved by the institutional review board at NYU Langone Medical Center.

Study Population

We recruited women who were over age 21, first time diagnosis of breast cancer (Stage I-III), and scheduled for surgical treatment, including lumpectomy or mastectomy, sentinel lymph node biopsy (SLNB) or axillary lymph node dissection ALND). Women with metastatic cancer (Stage IV), prior history of breast cancer and lymphedema, and bilateral breast cancer were excluded. Between April 2010 and June 2012, we prospectively enrolled 140 women and followed the participants for 12 months after surgery. All the participants received the *The-Optimal-Lymph-Flow* program.

The-Optimal-Lymph-Flow Program

The-Optimal-Lymph-Flow is a patient-centered educational and behavioral program focusing on self-care risk reduction strategies to promote lymph flow and optimize BMI by targeting known lymphedema risk of compromised lymphatic system and high BMI. Easy-to-learn self-care strategies include shoulder mobility exercises to promote shoulder function, muscle-tightening-breathing, muscle-tightening-pumping exercises, and large muscle exercises to promote lymph flow and drainage, as well as general instructions to encourage nutrition-balanced (more vegetables and fruits) and portion-appropriate diet (feeling 75% full for each meal) to strive for maintaining pre-operative BMI. Table 1 describes the self-care strategies and physiological rationales. Trained nurses delivered the intervention during a 30-minute face-to-face meeting with each patient. Patients demonstrated back the shoulder exercises, muscle-tightening-breathing, and muscle-tightening-pumping exercises.

Outcome Evaluation

The study outcomes were LV change by infra-red perometer and BMI by a bioimpedance device at pre-surgery baseline, 2-4 weeks after surgery, 6-month, and 12-month follow-up after surgery as well as safety, feasibility, and acceptability of *The-Optimal-Lymph-Flow* program. Lymphedema was defined as a perometer measurement of 10% LV increase from baseline in the ipsilateral arm in comparison with the changes in the contralateral arm, using the formula: $\text{Lymphedema} = (\text{Ipsilateral Frustum LV}_{\text{Follow-up}} / \text{Ipsilateral Frustum LV}_{\text{baseline}}) / (\text{Contralateral Frustum LV}_{\text{Follow-up}} / \text{Contralateral Frustum LV}_{\text{baseline}})$ [17-18]. Because even a 5% LV increase enables detectable differences in quality of life and symptom reporting [4, 16-17], participants with a perometer measurement of 5%–<10% LV increase during any follow-up assessment were encouraged to increase the frequency of muscle-tightening-breathing and pumping exercises until the LV returned to preoperative level verified by a perometer measurement in 4 weeks. Participants with a perometer measurement 10% LV increase during any follow-up assessment were referred for lymphedema therapy, usually consisting of *Complete Decongestive Therapy* [19].

Data Collection Procedure

We collected data on demographic and clinical information, LV and BMI at pre-surgery baseline, 2-4 weeks, 6-month, and 12-month after surgery. An electrical bioimpedance device (InBody 520, Biospace Co., Ltd) was used to measure the participants' weight, BMI was calculated using the formula: weight (kg) / height (m²).

Infra-red Perometry 350S (Juzo, Cuyahoga Falls, OH) was performed on each arm as it is held horizontally. The perometer maps a 3-dimensional graph of the affected and non-affected limbs using numerous rectilinear light beams, and interfaces with a computer for data analysis and storage. A 3-dimensional limb image was generated and limb volume calculated. This optoelectronic method has a standard deviation of 8.9 ml (arm), less than 0.5% of LV with repeated measuring [16-17].

Safety of The-Optimal-Lymph-Flow program was assessed by asking the participants if the program created any discomfort or injury to them at each follow-up visit. Feasibility of the program was evaluated in terms of intervention delivering time by the trained nurses. Acceptability of the program was assessed by asking the participants the following questions: if the program helped the participants to (1) understand how to reduce the risk of lymphedema; (2) reduce the fear and anxiety of developing lymphedema; and (3) develop a plan to reduce the risk of lymphedema. Acceptability of the program was also assessed by the participants' practice of the risk reduction behaviors during the study period. A structured interview guide (*Lymphedema Risk Reduction Behavior Checklist*) was used to quantitatively and qualitatively assess patients' practice of risk reduction behaviors at the study endpoint of 12-month after surgery[13].

Data Analysis

Characteristics of the participants were summarized using descriptive statistics (means, standard deviations for continuous variables and frequency distributions and proportions for qualitative variables). Distributions of baseline patient demographic and clinical characteristics were compared for patients with SLNB and ALND using Chi-Squared tests for contingency tables and one-way analysis of variance for continuous variables. All statistical tests were conducted at the 0.05 significance level (2-sided) and 95% confidence intervals (CI) were provided for estimates.

Mixed effects regression models were used with subject specific intercepts (and slopes if appropriate) with fixed effects of time to evaluate the changes from baseline in outcome measures of LV and BMI over time. Participants were included as a random effect to allow for the incorporation within a subject as well as missing data over time [23]. Correlations were examined to identify potential interactions and redundancies among variables. Predictive covariates (such as age, ethnicity, lumpectomy vs. mastectomy, SNLB vs. ALND) were included in the models.

Results

Participants

A total of 197 women responded to the study invitation. Of the 197 patients screened, 178 (90.4%) were eligible for the study and 140 (78.7%) of those eligible consented to participate in the study. Those patients who were eligible but did not enroll in the study provided the following reasons: significant travel distance, difficulty in finding transportation or childcare, or stress from cancer diagnosis.

Among the 140 patients, 134 patients completed the study with a 4% attrition rate. The reasons for those who did not complete the 12-month follow-up were significant travel distance (3 patients), death from cardiac related event (1 patient), and withdrawal of consent due to stress from chemotherapy (2 patients). Since lymph node procedures are major risk factors for lymphedema [3,18], we stratified the participants into axillary node dissection (ALND) group (n=81; 58%) and sentinel lymph node biopsy (SLNB) group (n=59; 42%). Participants in the two groups were comparable with no significant differences in terms of education, marital status, and employment status. The participants in the SLNB group were significantly older than those in the ALND group. Significantly more women in the ALND group had mastectomy, more lymph nodes removed, and chemotherapy. No significant differences were found between ALND and SLNB groups in terms of body weight and BMI and radiotherapy. Cancer surgery was performed on the side ipsilateral to the dominant hand in 67 patients (48%) and on the side of the nondominant hand in 73 patients (52%). Table 2 provides a summary of these comparisons of demographic and clinical characteristics.

Lymphedema and Limb Volume Changes

At the study endpoint of the 12-month following cancer surgery, no patients in the SLNB and ALND group exceeded 10% LV increase. Two patients (3%) in the SLNB group had 10% LV increase at the 2-4 weeks post-surgery visit; 2 patients (2%) in the ALND group had 10% LV increase at 6-month follow-up. All of the four women with 10% LV increase at the 2-4 weeks post-surgery and at the 6-month visit decreased their LV to <5% at the 12-month visit. Among the 12 patients (8.5%) with >5%-<10% LV increase at the 6-month follow-up, all the patients decreased their LV to <5% at the 12-month follow-up but one patient sustained 6% LV increase. Two patients with 0-<5% LV at the post-surgery visit progressed to >10% LV increase at the 6-month visit but decreased to <5% at the 12-month visit; 7 patients without LV increase in the ALND group at the 6-month visit progressed to >5%-<10% LV increase at the 12-month visit.

For the affected and unaffected limbs, LV decreased monotonically over the time (mixed effects regression analyses: affected $p=0.0004$, unaffected $p<0.0001$), adjusted for age, ethnicity, SLNB vs. ALND, and mastectomy vs. lumpectomy. African American participants had the highest LV while Asian American participants had the lowest LV for both affected and unaffected limb at the baseline and at the 12-month visit. Figure 1.

Among the 8 patients who received lymphedema therapy, two of the 4 patients from the SLNB group had >10% LV increase; two of the 4 patients from the ALND group had 10% LV increase. Only 3 patients wore a compression sleeve daily and 2 patients used bandaging

when the swelling was worse. Among 52 participants who had air travel at least once during the 12-month study period, 50 patients did travel without wearing a compression sleeve and glove and they did not develop lymphedema, among whom 30 patients underwent ALND. Among the 2 patients, one patient who wore a compression sleeve and glove during air travel did not develop lymphedema, and the other patient who only wore a compression sleeve did develop lymphedema in the affected hand during the travel. Her hand swelling returned to normal in 4 weeks after daily muscle-tightening-breathing and pumping exercises.

Body Weight and BMI

Participants' body weight did not change significantly over the 12 month study period ($p=0.41$ after adjustment for age, ethnicity, SLNB vs. ALND, and mastectomy vs. lumpectomy). Ethnicity was significantly related to weight ($p<0.001$); African American women had higher body weight on average at the baseline. There was no significant change in participants' BMI over the 12 months from the pre-surgery baseline, post-surgery, 6-month and 12-month follow-up visit (adjusted for age, ethnicity, SLNB vs. ALND, and mastectomy vs. lumpectomy; mixed effects regression analysis), participants' BMI were close at four time points ($p=0.67$). Age and ethnicity were significantly related to BMI at pre-surgery baseline (Age $p=0.03$, Ethnicity $p<0.001$). Older patients and African American patients had higher BMI (Age $p=0.004$; Ethnicity $p<0.001$). Figure 2.

Safety, Feasibility, and Acceptability

At each follow-up visit, no participants reported injury or discomfort associated with The-Optimal-Lymph-Flow program. It took about 30 minutes for the trained nurses to deliver the program. Among the 134 patients who completed the study, more than 90% of the participants performed the risk reduction strategies. Quantitative and qualitative evaluation provided positive support for *The-Optimal-Lymph-Flow* program. See Table 3.

Discussion

Annually, more than 230,000 women are diagnosed with breast cancer in the US [20]. A large number of women each year still face the life-time risk of developing this progressive and debilitating condition even with the most conservative estimates suggesting that 3% of women with SLNB and 20% of those with ALND developed lymphedema at 12 months following breast cancer surgery [18,21-22]. Provision of patient education and risk reduction strategies is critical to the improvement of patients' quality of life.

Although clinical and personal risk factors have been identified, rational preventive strategies derived from scientific evidence are lacking. Consistent with previous research [16,18], preoperative baseline and consecutive follow-up measurements are vital to successfully detect fluid accumulation. In our study, patients were provided with their measurements at each time point and encouraged to continue *The-Optimal-Lymph-Flow* strategies. Our study demonstrated safety, acceptance, and feasibility of self-care behaviors to promote lymph flow and optimize BMI. This is an important initial step targeting identified lymphedema risk of compromised lymphatic system and high BMI. Our study

provided initial evidence that self-care strategies may be effective, pragmatic, and low-cost for reducing lymphedema risk.

Over 50% of breast cancer survivors were found to be exceedingly worried about their risk of developing lymphedema [18]. Over 90% of our patients reported that *The-Optimal-Lymph-Flow* program helped them to reduce their fear and anxiety of developing lymphedema. Perhaps, one of the contributions of our study is that the *The-Optimal-Lymph-Flow* program has increased patients' awareness of lymphedema, demonstrated patients' willingness to perform self-care strategies and feeling empowered and less anxious. Such findings are clinically relevant to support that patients should be educated regarding their lymphedema risk. Furthermore, empowering patients by focusing on what patients can do rather than what patients can avoid perhaps is the key, as our patients stated in the qualitative data. Table 3.

The full range of factors that influence the etiology and progression of lymphedema remains unknown and this knowledge gap has hindered the development of effective risk reduction strategies. Although some LV changes in our study might be due to the natural fluctuation during the first year of cancer surgery, in comparison to the most recent data that 3% of women with SLNB and 20% of those with ALND developed lymphedema with the same definition as in our study, i.e. >10% LV increase at 12 months following breast cancer surgery [18], no patients in our study increased 10% LV at the 12-month follow-up. Cumulatively, only 2 patients with SLNB (3%) and 2 patients with ALND (2%) had measurable lymphedema (>10% LV increase) at 2-4 weeks and at 6-month follow-up. Research demonstrated that women with mild lymphedema are more prone to progress to severe lymphedema [3]. In our study, among the 12 patients with >5%-<10% LV increase at the 6-month follow-up, all the patients decreased their LV to <5% at the 12-month visit but one patient from ALND group sustained 6% LV increase. Our patients demonstrated that self-care strategies helped to maintain pre-operative LV and halt the progression of fluid accumulation. It should be noted that general instructions on having nutrition-balanced and portion-appropriate diet and physical activities daily or weekly was effective for our patients to maintain their pre-operative BMI.

We recognize that this pilot study was limited because it did not have a randomized-controlled design. The strengths of our study included well-designed intervention targeting known lymphedema risk of compromised lymphatic system and high BMI, well-defined outcomes, adequate sample size for a feasibility study, prospective and consecutive repeated measurement at meaningful time points, as well as quantitative and qualitative evaluation of the program. It should be noted that the majority of patients discontinued shoulder exercises at 12-month follow-up. Our patients perceived that either there was no need or forgot doing the shoulder exercises because of their shoulder and limb function returned to the pre-surgical level. One acceptance testing was to discern which behaviors was initiated, continued, or discontinued by the participants. Our data showed that perhaps shoulder exercises might be discontinued once the function of the affected shoulder and limb has returned to pre-surgical level. Nevertheless, future research requires a larger study with a randomized-controlled design to evaluate the overall effectiveness of *The-Optimal-Lymph-Flow* program and to determine the dosage and contribution of individual component of the

program. Research should continue providing evidence on the need to avoid air travel or wear compression garments during air travel and the ethnic differences in limb volume.

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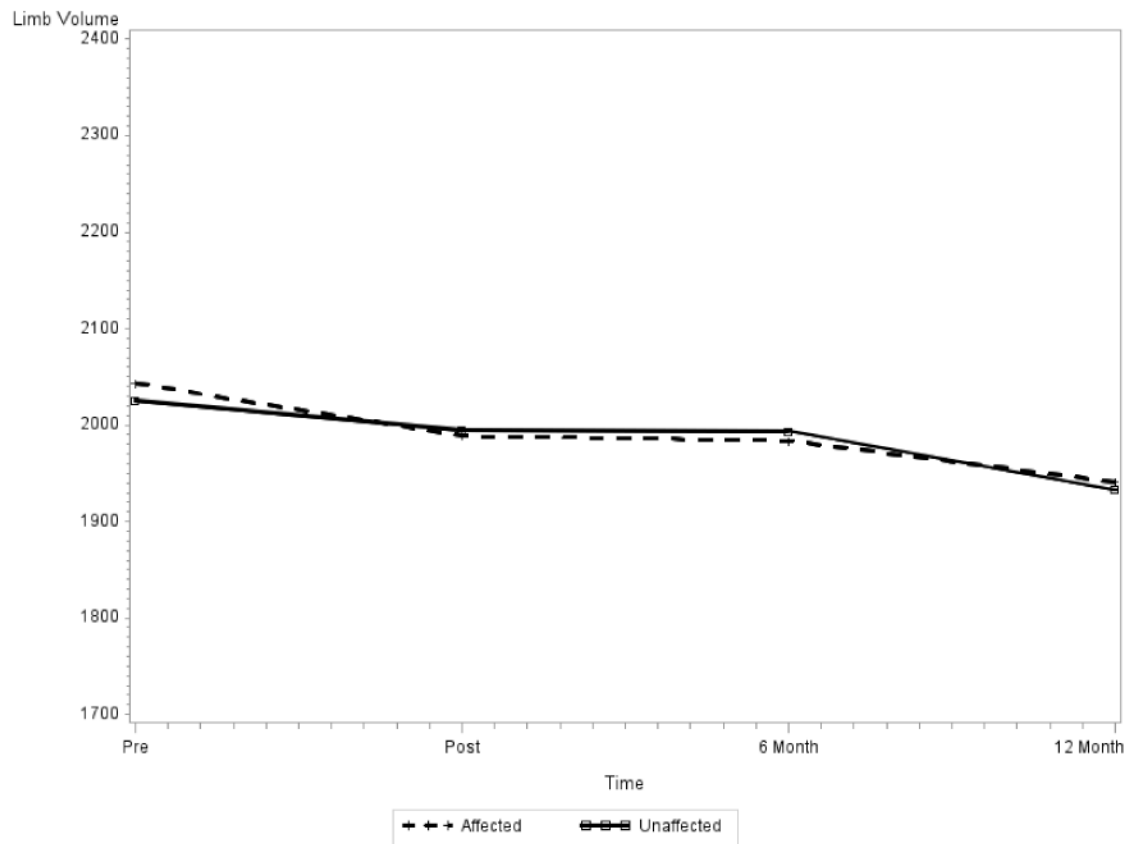


Figure 1. Limb Volume Changes Over 12-Month Time Period

Note: As shown above, the limb volume is decreasing over time, for both affected and unaffected arms (affected $p=0.0004$, Unaffected $p<0.0001$)

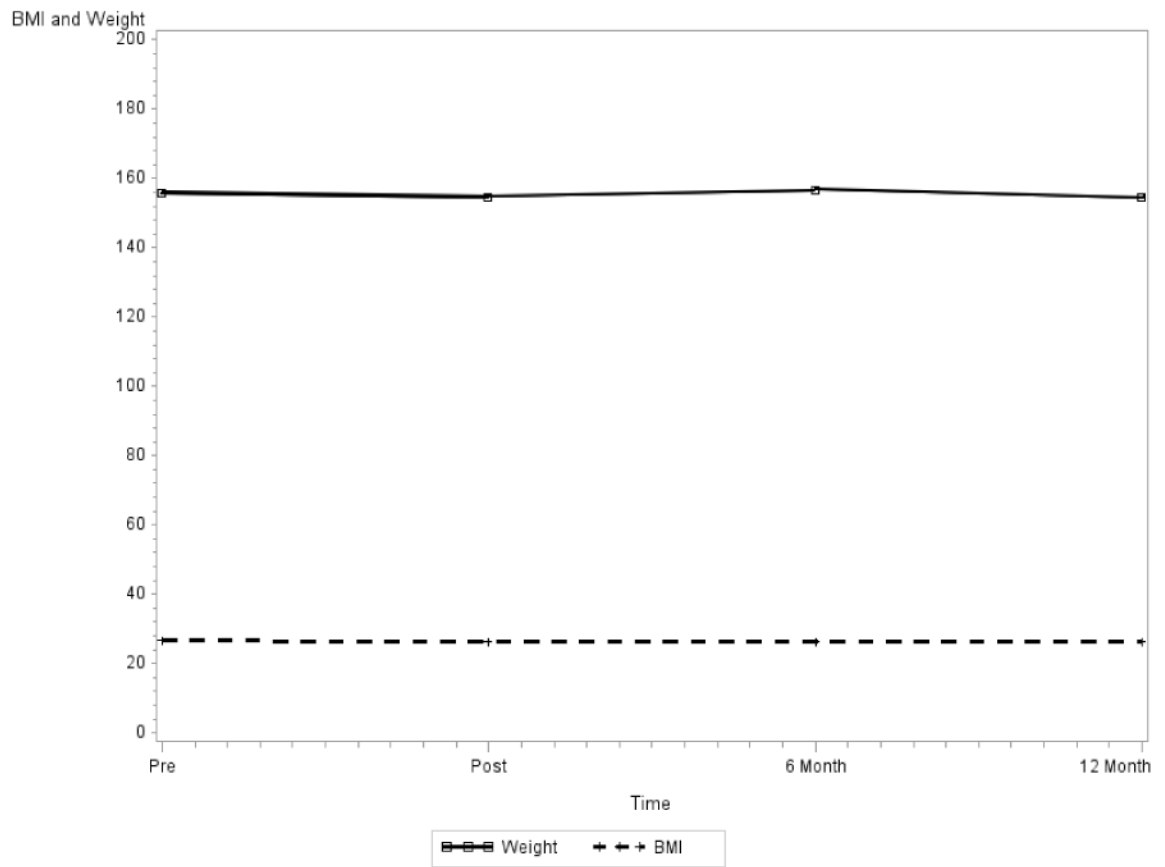


Figure 2. Body Mass Index and Weight Over 12-Month Time Period

Note: BMI and Weight are not significantly changing over time (BMI $p=0.6650$, Weight $p=0.4086$)

Table 1
The-Optimal-Lymph-Flow Program Strategies and Rationales**

	**Risk Reduction Strategies	Rationales	Frequency & Situations
Promoting lymph Flow	<ul style="list-style-type: none"> Muscle-Tightening Deep Breathing 	<ul style="list-style-type: none"> The whole body lymph fluid has to be drained through the lymphatic ducts above the heart. Muscle-tightening-deep-breathing stimulates lymphatic ducts and help lymph fluid drain. Lymph fluid drains when muscles move. Muscle-tightening-deep-breathing creates the whole body muscle movements that create muscle milking and pumping action and help to drain lymph fluid. 	<ul style="list-style-type: none"> At least twice a day in the morning & at night before brushing teeth or as much as the patient wants throughout the day. Air-Travel: before take-off and after landing Sedentary life-style: At least every 4 hours
	<ul style="list-style-type: none"> Muscle-Tightening Pumping 	<ul style="list-style-type: none"> Muscle-tightening pumping exercises create arm muscle pumping. This helps lymph fluid flow and decreases the fluid build-up in the arms. Muscle-tightening pumping exercises build the arm muscle that helps lymph fluid flow and drain. 	<ul style="list-style-type: none"> At least twice a day in the morning & at night before brushing teeth or as much as the patient wants throughout the day. Air-Travel: before take-off and after landing Sedentary life-style: At least every 4 hours
	<ul style="list-style-type: none"> Large Muscle Exercises: Walking, Marching at home, Dancing, Swimming, Yoga, Tai Chi. 	<ul style="list-style-type: none"> Large muscle exercises create muscle milking and pumping to promote overall body lymph fluid flow and drain. 	<ul style="list-style-type: none"> At least 10-minutes daily. Air-Travel: get up and walk around for flight over 4 hours. Sedentary life-style: Get up and walk at least every 4 hours.
Improving Limb Functional Status	<ul style="list-style-type: none"> Shoulder Exercises 	<ul style="list-style-type: none"> Improved limb mobility after surgery facilitates 	<ul style="list-style-type: none"> One week after surgery if there is no surgical drains

	** Risk Reduction Strategies	Rationales	Frequency & Situations
		local muscle movements that create muscle milking and pumping to promote local limb lymph fluid flow and drain.	<p>or after the surgical drains are removed.</p> <ul style="list-style-type: none"> • At least twice a day until limb functions are returned to normal. • Whenever limb mobility is limited throughout the recovery.
Optimizing BMI	<ul style="list-style-type: none"> • Large Muscle Exercises 	<ul style="list-style-type: none"> • Daily large muscle exercises, such as walking, running, swimming, help to achieve optimal weight and body mass index. 	<ul style="list-style-type: none"> • At least 30-minutes 3 times a week or daily
	<ul style="list-style-type: none"> • Nutrition-balanced (i.e. more vegetables and fruits) and portion - appropriate diet (feeling 75% full for each meal) 	<ul style="list-style-type: none"> • Overweight or obesity is an important risk factor for lymphedema. Having extra weight makes it difficult for lymph flow and drain. This can lead to extra lymph fluid build-up. 	<ul style="list-style-type: none"> • Each meal daily • It is important to talk to the nutritionist who can help to find a proper weight reduction programs. Although there are a lot of weight reduction programs, each person may respond differently to each program.

** For step-by-step instruction for each exercise, please contact the corresponding author.

Table 2
Demographic and Clinical Characteristics of Participants by Type of Node Dissection

	Total N=140	SLNB n=59	ALND n= 81	p Value*
	Mean (SD; Range)	Mean (SD; Range)	Mean (SD; Range)	
Age at Diagnosis (in years)	56.0 (11.8; 25-84)	58.5 (10.7; 42-84)	54.1 (12.3; 25-81)	0.03
Body Weight (in pounds)				
Before Surgery	155.8 (36.9; 104.7-278.6)	152.3 (35.9; 104.7-277.3)	157.7 (37.8; 106-278.6)	0.48
2-4 Weeks After Surgery	154.9 (36.1; 102.9-279.9)	153.0 (36.3; 102.9-273.4)	156.3 (36.1; 106.9-279.9)	0.60
At 6 Months	153.5 (35.0; 102.7-282.8)	152.1 (35.8; 102.7-277.5)	154.6 (34.7; 108.7-282.8)	0.68
At 12 Months	154.8 (36.1; 104.9-284.4)	153.3 (36.6; 106.2-281.8)	155.8 (35.7; 104.9-284.4)	0.69
Body Mass Index (BMI)				
Before Surgery	26.6 (5.6; 17.7-46.1)	26.6 (5.7; 17.7-46.1)	26.6 (5.6; 18.1-41.4)	0.96
2-4 Weeks After Surgery	26.4 (5.5; 17.1-45.5)	26.5 (5.8; 17.1-45.5)	26.3 (5.3; 17.9-41.6)	0.83
At 6 months	26.2 (5.3; 17.1-46.2)	26.5 (5.7; 17.1-46.2)	26.0 (5.0; 18.6-40.1)	0.60
At 12 months	26.4 (5.5; 17.1-46.9)	26.7 (5.9; 17.9-46.9)	26.2 (5.2; 17.1-39.7)	0.62
Highest Level of Education	n(%)	n(%)	n(%)	0.28
High School or Below	25 (18)	12 (20)	13 (16)	
Associate's Degree	22 (16)	9 (15)	13 (16)	
Bachelor's Degree	51 (36)	20 (34)	31 (38)	
Master's Degree	30 (21)	12 (20)	18 (22)	
Doctoral Degree	12 (9)	6 (10)	6 (8)	
Marital Status				0.17
Married	77 (55)	32 (54)	44 (55)	
Partnered	6 (4)	0 (0)	6 (7)	
Divorced/Separated	19 (14)	8 (14)	11 (14)	
Widowed	13 (9)	9 (15)	4 (5)	
Single or Never Partnered	25 (18)	10 (17)	15 (19)	
Ethnicity				
Asian	18 (13)	8 (13)	10 (12)	
African American or Black	13 (9)	3 (5)	10 (12)	
White	102 (73)	46 (78)	56 (69)	
Hispanic/Latino	7 (5)	2 (3)	5 (6)	
Employment Status				0.70
Unemployed	45 (32)	20 (34)	25 (31)	

	Total N=140	SLNB n=59	ALND n= 81	p Value *
	Mean (SD; Range)	Mean (SD; Range)	Mean (SD; Range)	
Employed	95 (68)	39 (66)	56 (69)	
Surgery	n (%)	n (%)	n (%)	0.02
Mastectomy	21 (15)	7 (12)	14 (17)	
Lumpectomy	61 (44)	34 (58)	27 (33)	
Immediate Reconstruction	58 (41)	18 (30)	40 (50)	
Radiotherapy	94 (67)	37 (63)	57 (70)	0.35
Neoadjuvant chemotherapy	17 (12)	0 (0)	17 (21)	<u>0.05</u>
Adjuvant chemotherapy	55 (39)	11 (19)	44 (54)	<u>0.05</u>
Number of nodes removed	Median 8	Median 2	Median 13	<u><0.001</u>

* One-way analysis of variance was used for continuous variables and Chi-square tests for contingency tables.

Table 3
Quantitative and Qualitative Evaluation of *The-Optimal-Lymph-Flow* Program

	n (%)		n (%)	
**Risk Reduction Strategies	Yes		No	
Have you been performing Muscle-Tightening Deep Breathing?	•Daily	82 (62%)	7 (5%)	
	•2-3 Times a Week	33 (25%)		
	•When discomfort occurs	11 (8%)		
Have you been performing Muscle-Tightening Pumping?	•Daily	83 (62%)	5 (4%)	
	•2-3 Times a Week	30 (23%)		
	•When discomfort occurs	15 (11%)		
Have you been performing Large Muscle Exercises?	•Daily	66 (49%)	31 (23%)	
	•2-3 Times a Week	37 (28%)		
Have you been performing Shoulder Exercises?	•After Surgery	134 (96%)	•After Surgery	6 (4%)
	•12-Month after Surgery	25 (18.7%)	•12-Month after Surgery	109 (81.3%)
Have you been eating nutrition-balanced and portion -appropriate diet?	•Daily	106 (79%)	5 (4%)	
	•2-3 Times a Week	24 (18%)		
**No significant differences in practicing the risk reduction strategies between patients undergoing SLNB and ALND.				
*** <i>The-Optimal-Lymph-Flow</i> Program...	Yes		No	
Helped me to understand how to reduce my risk of lymphedema.	121 (90.3%)		13 (9.7%)	
Helped me to reduce my fear and anxiety of developing lymphedema.	117 (87.3%)		17 (12.7%)	
Helped me to develop a plan to reduce my risk of lymphedema.	105 (78.4%)		29 (21.6%)	
Created injury or discomfort to me.	0 (0%)		134 (100%)	
***No significant differences in positive responses between patients underwent SLNB and ALND.				
Summary of Themes from Qualitative Data				
123 (91.8%) participants Provided Qualitative Evaluation of <i>The-Optimal-Lymph-Flow</i> Program				
Themes	Representative Quotes			
Empowerment	<p>** "Being aware of lymphedema risk and informed about it helped me tremendously. I didn't know what lymphedema was... I felt more in control rather than just hoping I would not get lymphedema. I was doing something to prevent it. It gave me a sense of empowerment."</p> <p>** "The best thing I have done for myself was to participate in <i>The-Optimal-Lymph-Flow</i> program. I only had 1 node removed. I thought that I am fine. During the radiation, I had slight swelling in my arm and I started religiously doing the breathing and pumping exercises. It worked and now I am doing the exercises every day because I feel good after doing the exercises. Without the program, I probably would be like my friend who has a huge arm now."</p> <p>** "I truly believe that participating in <i>The-Optimal-Lymph-Flow</i> program has been the pillar of strength for me following my mastectomy and lymph node dissection. The program enabled me to feel armed with knowledge and preventive measures to keep me from getting lymphedema."</p>			

	n (%)	n (%)
**Risk Reduction Strategies	Yes	No
Easy to Do	** "It is a simple program and awareness of the result is also motivating." ** "I was very pleased that I could reduce my risk with very simple techniques (breathing, pumping, & walking)." ** "The pumping & breathing are something I can do. I can do more and feel better."	
Skills Building	** "Wonderful to have been aware before surgery of the exercises and get into the habit of doing them. After surgery, I didn't have to review the direction and just began to do what I had been doing already." ** "I am doing the right exercise (breathing and pumping) on the daily basis. I feel good and I feel that I owe it to myself." ** "Being aware of factors that contribute to developing lymphedema and specific measures to alleviate symptoms has been instrumental in reducing any swelling. I have experienced and have motivated/aware of making choice to reduce my risk."	
Psychological Benefits: Fear and Anxiety Relief	** "This program was wonderful for not making me feel like a victim and being able to take charge of my own feeling." ** "...eased my concerns about lymphedema." ** "Give me more confidence and motivation to get better." ** "Helps me to be more aware of having cancer and understanding the way it is affecting my day-to-day living. The process of measurement and follow-ups are essential to maintain good health. I have a whole new outlook on life."	
Forget Doing the Exercises	** "In the beginning I followed the directions for breathing and pumping and other precautions carefully. After about 4 months I became casual because I feel very good." ** "I forget doing the exercises a lot because my arm feels good."	