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Early Implementation of Exercise to Facilitate Recovery After Breast Cancer Surgery
A Randomized Clinical Trial

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IMPORTANCE Recovery of shoulder function following breast cancer surgery is crucial for physical functioning and quality of life. While early implementation of shoulder rehabilitation exercises may enhance recovery, the optimal timing and exercise program remain unclear.

OBJECTIVE To investigate whether an early exercise intervention, initiated 1 day postsurgery and continued for 1 month through subsequent visits, could improve shoulder range of motion (ROM) and strength in patients with breast cancer.

DESIGN, SETTING, AND PARTICIPANTS A parallel-group, 2-arm randomized clinical trial was conducted between June 2020 and October 2021 at the Breast Cancer Center in Seoul, South Korea. Fifty-six patients (of 119 screened) with early-stage breast cancer who were scheduled for partial or total mastectomy were randomized into a tailored resistance exercise group (n = 28) or a usual care group (n = 28). Data were analyzed from November 2021 to June 2022.

INTERVENTIONS The exercise intervention commenced 1 day postsurgery and consisted of 4 supervised exercise education sessions corresponding with surgeon visits and daily home-based exercises for the first postoperative month. Tailored programs, including stretching and strength exercises, were adjusted based on individual shoulder function recovery status.

MAIN OUTCOMES AND MEASURES Primary end points were shoulder ROM and strength at 1 and 6 months postsurgery. Physical activity, body composition, and quality of life were assessed at 6 months.

RESULTS Of 56 patients randomized (mean [SD] age, 50.3 [6.6] years), 54 completed the trial (96%), with 100% and 97% compliance to supervised and home-based exercise sessions, respectively. At 1 month postsurgery, 19 (67.9%) in the exercise group had fully recovered shoulder strength compared to 1 (3.6%) in the usual care group ($P < .001$). At 6 months, 22 (78.6%) in the exercise group had fully recovered shoulder ROM and 24 (85.7%) had fully recovered strength compared to 6 (21.4%) and 5 (17.9%), respectively, in the usual care group ($P < .001$). The exercise group exhibited less loss in muscle mass and improved physical activity and quality of life compared to the usual care group.

CONCLUSION AND RELEVANCE In this trial, 1-month tailored exercise program, initiated immediately after breast cancer surgery and supplemented with supervised sessions coinciding with surgeon visits, significantly improved shoulder function in patients with breast cancer.

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Visual Abstract
Invited Commentary
Supplemental content

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Most women diagnosed with early-stage breast cancer receive surgery as part of their cancer treatment.[1,2] Advances in surgical treatment have positively impacted breast cancer survivorship,[1,3] although breast cancer surgery still has adverse outcomes ranging from acute discomfort to chronic complications.[4-8] Approximately one-third of women experience surgery-induced adverse effects, such as restricted shoulder range of motion (ROM), decreased shoulder strength, pain, lymphedema, and axillary web syndrome, which may lead to depression and nervousness.[9-13] Other common adverse effects of breast cancer surgery include arm weakness, fatigue, and general impairment of daily activities.[14,15] Complications after surgery or a prolonged recovery period may even delay the start of adjuvant treatment.[16]

One month after breast cancer surgery marks a pivotal time point in the patient's trajectory for recovery of the surgical site and preparation for subsequent treatments.[8] At this time, rehabilitation exercise interventions and medical treatments are necessary.[17-20] Early shoulder mobilization after total mastectomy has been shown to prevent shoulder dysfunction and does not increase the risk of surgical complications.[17] After surgery, patients with breast cancer are recommended to start exercise to improve joint stiffness, muscle atrophy, shoulder function, and quality of life.[21-25]

Few studies have examined the integration of exercise into medical services to facilitate the postsurgical recovery of patients. Time points vary among studies from 1 day postsurgery to several weeks postsurgery. Some studies initiated exercise 1 to 3 days postoperatively,[26-28] while others initiated exercise several weeks after surgery.[29-32,34] A few studies[28,33] examined the effect of exercise therapy immediately after surgery, and the results were inconsistent. To date, to our knowledge, no study has examined the effects of home-based exercise with minimal supervision initiated 1 day after surgery on recovery of shoulder function at 1 and 6 months after surgery.

The primary objective of this study was to evaluate whether early implementation of home-based exercise intervention with minimal supervision would improve shoulder ROM and strength after surgery for breast cancer. Secondary objectives were to examine the efficacy of the intervention on physical activity behavior, body composition, and quality of life at 6 months postsurgery. We hypothesized that 1 month of home-based exercise, supplemented with 4 supervised exercise education sessions, would facilitate the recovery of shoulder dysfunction at 1 and 6 months postsurgery.

Key Points

Question Does a home-based exercise intervention program enhance shoulder function recovery at both 1 month and 6 months postsurgery?

Findings In this randomized clinical trial, significantly more participants in the exercise group regained 95% of their shoulder strength after 1 and 6 months postsurgery vs the usual care group.

Meaning The findings suggest that an early tailored home-based exercise intervention supplemented with supervised sessions during surgical visit immediately after breast cancer surgery was effective.

Methods

Study Design and Participants

We conducted a parallel-group, 2-arm randomized clinical trial at the Breast Cancer Center, a tertiary referral center in Seoul, South Korea. Study eligibility included women aged 19 to 70 years with histologically confirmed stage IV or lower breast cancer who were scheduled to receive a partial or total mastectomy and had the ability to provide written informed consent in Korean. The Institutional Ethics Review Board of Severance Hospital approved the trial, and all participants provided written informed consent prior to trial commencement. The protocol is in Supplement 1.

The primary outcomes (shoulder ROM and strength) were measured at 6 time points (1 day before surgery, postoperative day 1, at the first week [first outpatient visit], at the second week [second outpatient visit], 1 month [third outpatient visit], and 6 months after surgery [fourth outpatient visit]) (eFigure 1 in Supplement 2). The Shoulder Pain and Disability Index (SPADI), quality of life, body composition, and physical activity behavior assessments were administered at the same times as the shoulder ROM and strength assessments, except at postoperative day 1.

Randomization and Blinding

Patients were randomly assigned to either the exercise group or usual care group in a 1:1 ratio. We randomized patients using a permuted block design with stratification by age and type of surgery. Allocation concealment was ensured using sequentially numbered, sealed, and opaque envelopes. Exercise interventionists were not blinded to treatment assignment. Outcome assessors for ROM and strength were not blinded to treatment assignment; however, they were trained in the importance of standardizing assessment protocols.

Study Interventions

The exercise intervention and development process are described in full detail in the eMethods in Supplement 2 (exercise protocol) and eFigure 1 in Supplement 2. In brief, the exercise intervention consisted of tailored, home-based stretching and resistance exercises using patients' own body weight and 4 supervised exercise sessions at postoperative days 1-2, 7-10, 14-20, and 21-30, coinciding with surgeon visits. A certified exercise specialist performed shoulder ROM and strength assessments and supervised exercise for 20 to 30 minutes in all 4 sessions. On all other days, patients engaged in exercise at home using an exercise diary and QR code describing the exercise program in video format. On the following visit, the exercise specialist checked the diary and provided exercise counseling. The exercise consisted of a 4-stage program progressively increasing in intensity. The intensity was determined by the patient's shoulder function (ROM and strength) and other considerations (ie, remove drainage volume, wound healing, and surgery method). The

usual care group received an information booklet regarding breast care, breast cancer treatment, daily activities, and self-examination. Information on daily activities included postoperative wound care, nutrition, and exercises. The booklet included detailed exercise explanations after surgery; however, no personalized exercise education or training was provided. The usual care group received a personalized exercise intervention after the 6-month study period.

Outcomes

Primary Outcomes

Shoulder passive ROM was assessed in both arms using a goniometer (goniometer bending iron 29-5900) and standardized protocol.[35] Shoulder strength (in pounds) in each arm was measured with a handheld dynamometer (j-tech Medical Industries).[36] Peak muscle force was measured using maximal voluntary isometric contraction in flexion, abduction, and extension. Shoulder function measurements were performed twice with both the affected and unaffected arms, and the average values were used in the analysis. We defined full shoulder function recovery as achieving at least 95% of their presurgery shoulder ROM and strength levels.

Secondary Outcomes

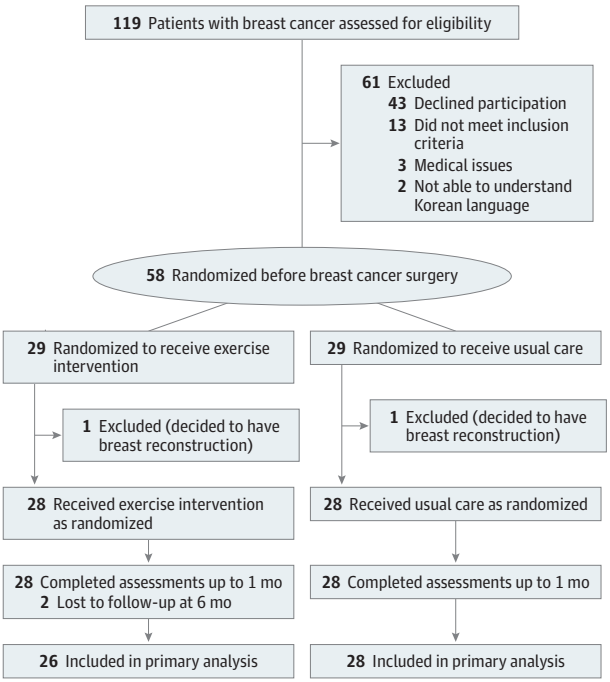
Shoulder pain and disability were assessed using the SPADI. The SPADI is a self-administered questionnaire for shoulder pain with a total of 13 questions (5 assess shoulder pain and 8 assess disability).[37] Surgical complications within 6 months after surgery were monitored through a medical record review. Surgical complications included surgical infection, wound complications (eg, hematoma and wound dehiscence), seroma, lymphedema, and reoperation after breast cancer surgery. We also recorded the amount of drainage volume.

Body composition, including muscle mass and fat percentage, was measured with bioelectrical impedance (BIA) (Inbody 720; Bio-space). Physical activity behavior was measured using the Korean Global Physical Activity Questionnaire.[38] Quality of life was measured by the EuroQol-5 dimensions-5 level questionnaire (EQ-5D-5L). Additionally, EQ-5D-5L assessed overall health status using the visual analog scale (EQ-VAS). The Korean EQ-5D-5L used in this study has been validated in a previous study.[39]

Sample Size Calculation

We anticipated an effect size of 0.95, based on insights from our observational study and results from Kim et al,[40] which reported shoulder ROM of abduction on the affected arm at 1 month after surgery (mean [SD] exercise, 140.7 [46.0] vs mean [SD] usual care, 101.6 [35.2]). To detect this effect size, a total of 50 participants were initially calculated to be required. Considering a projected dropout rate of 12%, we aimed for a final sample size of 56 participants (with 28 participants in each group). This sample size calculation was based on a power of 0.90, a 2-tailed overall type I error rate of .05.

Figure 1. CONSORT Flow Diagram



Statistical Analysis

All analyses adhered to the intention-to-treat principle. To address missing data in the exercise group, the last observation carry-forward method was used. Additionally, a sensitivity analysis was conducted, excluding 2 data sets in which the previous measurement values were missing (eTables 1-3 and eFigure 2 in Supplement 2) We used repeated-measures 2-way analysis of variance to evaluate the interaction between group and time in the changing patterns of primary and secondary outcomes. We also conducted paired *t* tests to examine the difference between baseline and follow-up assessments, while independent *t* tests examined differences between groups at each assessment point. Significance was set at $\alpha = .05$. To account for multiple comparisons, we applied Bonferroni corrections by dividing the significance level by the number of tests conducted. This adjusted α level was used to determine statistical significance. All analyses were conducted using SPSS version 26 (IBM).

Results

Figure 1 shows the flow of patients through the study. A total of 119 eligible patients were initially assessed between June 28, 2020, and October 31, 2021. Of these, a total of 58 patients (mean [SD] age, 50.3 [6.6] years) met inclusion criteria and agreed to participate in the study. Two patients (1 in each group) were excluded, as they decided to have breast reconstruction after randomization. All other patients completed all assessments and attended all surgeon visits (ie, up to 1 month postsurgery outpatient visit). Two participants in the exercise group were not followed up with due to the absence of a scheduled

Table 1. Patient Characteristics at Baseline

Characteristic	No. (%)			*P* value
	Total (N = 56)	Exercise (n = 28)	Usual care (n = 28)	
Age, mean (SD), y	50.3 (6.6)	50.8 (6.8)	49.9 (6.5)	.63
Weight, mean (SD), kg	59.2 (9.9)	57.9 (10)	60.4 (9.9)	.35
BMI, mean (SD)	23.4 (3.3)	23.0 (3.3)	23.7 (3.4)	.42
Stage				
0	8 (14.3)	3 (10.7)	5 (17.9)	.56
1	31 (55.4)	17 (60.7)	14 (50)	
2	16 (28.6)	7 (25)	9 (32.1)	
3	1 (1.8)	1 (3.6)	0	
Surgery				
MRM	7 (12.5)	5 (17.9)	2 (7.1)	.41
TM with SLNB	12 (21.4)	4 (14.3)	8 (28.6)	
PM with ALND	7 (12.5)	3 (10.7)	4 (14.3)	
PM with SLNB	30 (53.6)	16 (57.1)	14 (50)	
Surgery site				
Right side	28 (50.0)	13 (46.4)	15 (53.6)	.59
Dominant arm	25 (50.0)	12 (48)	13 (52)	.91
Dissected lymph nodes, mean (SD)	6.4 (0.6)	6.5 (6.8)	6.4 (5.9)	.97
Surgery duration, mean (SD), min	110.9 (57.6)	100.1 (41.7)	121.7 (69.2)	.16
Neoadjuvant chemotherapy				
Yes	19 (33.9)	8 (28.6)	11 (39.3)	.40
Adjuvant treatment				
Herceptin	4 (7.1)	2 (7.1)	2 (7.1)	>.99
Chemotherapy	14 (25)	7 (25)	7 (25)	>.99
Radiation therapy	46 (82.1)	23 (82.1)	23 (82.1)	>.99
Hormone therapy	44 (79)	21 (75)	23 (82.1)	.75

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); MRM, total mastectomy with axillary lymph node dissection; PM with ALND, partial mastectomy with axillary node dissection; PM with SLNB, partial mastectomy with sentinel node biopsy; TM with SLNB, total mastectomy with sentinel node biopsy.

outpatient visit at the 6-month follow-up. The compliance rates for supervised and home-based exercise sessions were 100% and 96.7%, respectively, in the exercise group. The groups were balanced on stage, surgery methods, and neoadjuvant and adjuvant chemotherapy (**Table 1**). Data were analyzed from November 2021 to June 2022.

Shoulder Function

Figure 2 shows recovery in shoulder ROM and strength across the 2 groups. After 1 month, 19 patients (67.9%) in the exercise group demonstrated full recovery of strength (compared to presurgery levels) compared to 1 patient (3.6%) in the usual care group ($P < .001$). At 6 months follow-up, 22 (78.6%) of those in the exercise group demonstrated full recovery in shoulder ROM compared to 6 (21.4%) in the usual care group ($P < .001$). For shoulder strength at 6 months, 24 patients (85.7%) in the exercise group demonstrated full recovery compared to 5 (17.9%) in the usual care group ($P < .001$). When recovery of shoulder ROM was observed as separate movements (ie, flexion, abduction, and extension), recovery of ROM was better in all 3 movements in the exercise group compared to usual care group (eTable 4 in Supplement 2). For shoulder strength, patients in the exercise intervention demonstrated significant improvements in all 3 movements at the shoulder. Shoulder strength in flexion and abduction significantly differed from usual care group starting 1 week after surgery. Extension started to differ between groups 1 month after surgery. We observed similar results in sensitivity analysis (eFigures 2 and 3 in Supplement 2). A similar pattern was observed when analyzed according to the surgical method (axillary lymph node dissection vs sentinel lymph node biopsy) (eTables 5 and 6 in Supplement 2).

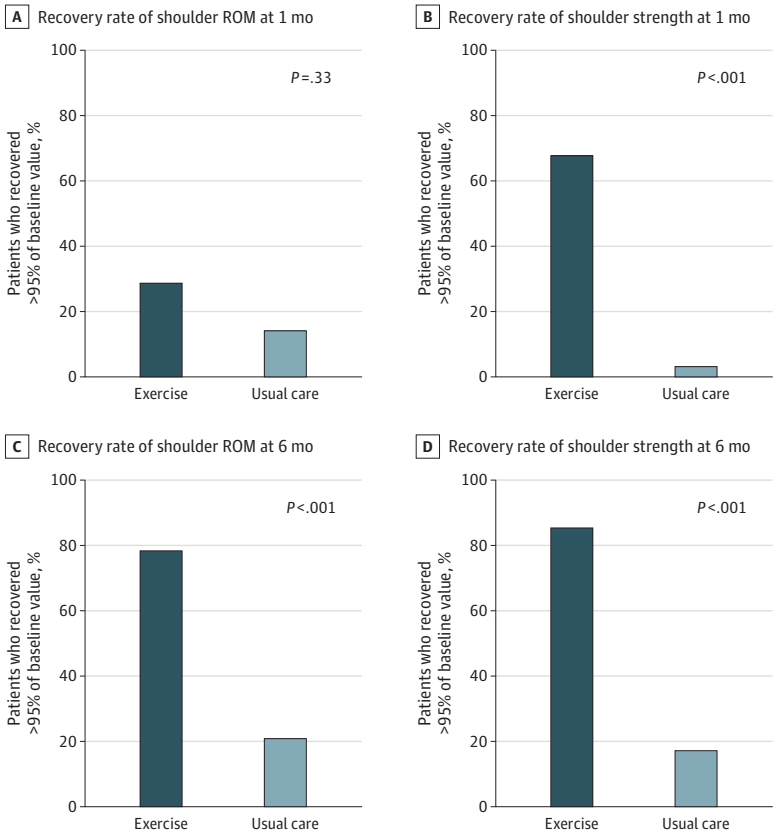
Secondary Outcomes

Both groups showed the highest score of shoulder pain, disability, and total SPADI at the first outpatient visit (1 week after surgery; postoperative days 7-10) and slowly decreased afterward (**Table 2**; eFigure 4 in Supplement 2). The exercise group was less likely to report their shoulder pain, disability, and total SPADI as severe than the usual care group. There was a significant difference between groups on total SPADI scores at each time point after 2 weeks postsurgery (eFigure 4 in Supplement 2). One month after surgery, the most frequent complication was seroma, followed by hematoma and axillary web syndrome. No significant differences were observed in surgical complications, the time of drainage removal, drainage volume, and lymphedema (Table 2).

The pattern of muscle mass change from before surgery to 6 months after surgery showed significant differences between groups (**Table 3**; eTable 3 in Supplement 2). Although both groups experienced a decrease in muscle mass, the usual care group exhibited a greater decline.

Significant within- and between-group differences were observed for moderate-intensity physical activity, total physi-

Figure 2. Recovery Rate of Shoulder Function in the Affected Arm



Data represented a recovery of shoulder function in the affected arm. We defined the recovery shoulder function as recovered above 95% of baseline value. The recovery rate of range of motion (ROM) and strength was calculated based on the sum of shoulder flexion, abduction, and extension in the affected arm.

cal activity, and sedentary behavior (Table 3; eTable 3 in Supplement 2). The exercise group reported increased physical activity postsurgery, whereas the control group reported decreased physical activity. Sedentary time decreased in the exercise group compared to no change in the usual care group at 1- and 6-month follow-up (Table 3).

Compared to baseline, quality of life was significantly lower 1 month after surgery in both the exercise and usual care groups and improved at the 6-month time point. Improvement in quality of life was significantly greater in the exercise group compared to the usual care group (Table 3).

Discussion

This randomized clinical trial demonstrated that a combined supervised and home-based exercise program improved both short- and long-term shoulder ROM and strength. One month after surgery, we found that 67.9% of patients with breast cancer in the exercise group fully recovered their shoulder strength compared to 3.6% in the usual care group. Patients in the exercise group continued to improve in shoulder function 6 months after surgery even though no further intervention was provided. At 6 months follow-up, 78.6% and 85.7% of those in the exercise group improved to 95% of their baseline shoulder ROM and strength, respectively. The tailored intervention was considered effective, with improvements in secondary outcomes, including SPADI score, body composition, physical activity behavior, and quality of life factors. Unlike the control group, the exercise group did not experience statistically significant decreases in muscle mass and quality of life; rather, these parameters either remained stable or demonstrated positive trends.

Our results corroborate previous studies in this area. A previous study[38] reported that stretching, strengthening, and physical activity effectively reduced shoulder disability after nonreconstructive breast cancer surgery.[41] We also observed significantly better shoulder function at 6 months. Another recent study[34] recommended earlier exercise rehabilitation, including initiating ROM exercise 3 days after surgery and progressive resistance training 3 weeks after surgery, rather than 7 days for ROM and 4 weeks for resistance training. Our study demonstrated that ROM and resistance training can be safely implemented if exercises are tailored to patients' shoulder ROM and strength. One recent systematic review[42] suggested that studies did not find any additional adverse effects of early mobilization in patients with breast cancer. The reported lymphedema incidence was higher in the early ROM group than in the delayed ROM group, yet incidence was not higher than in the usual care group. Our study did not observe any increase in drainage volume and incidence of lymphedema, seroma, or axillary web syndrome. Our study suggests that if exercise is safely implemented and tailored to the patient, risks of adverse effects may be minimized.

Table 2. Intervention Effects on Shoulder Pain and Disability Index (SPADI) Score, Surgical Complications, and Drainage Among Patients With Breast Cancer

Variable	Mean (SD)		*P* value
	Exercise (n = 28)	Usual care (n = 28)	
SPADI score			
Pain			
Baseline	1.1 (3.4)	2.0 (4.4)	.38
1 wk	32.1 (18.4)[a]	42.6 (21.2)[a]	.05
2 wk	21.5 (13.9)[a]	39.1 (21.5)[a]	.001
1 mo	13.9 (9.4)[a]	31.4 (19.7)[a]	<.001
6 mo	9.2 (9.7)[a]	14.2 (11.1)[a]	.06
Disability			
Baseline	0.4 (1.3)	0.2 (0.6)	.46
1 wk	20.2 (14.3)[a]	29.3 (16.4)[a]	.04
2 wk	10.4 (9.1)[a]	21.9 (16.2)[a]	.002
1 mo	6.4 (6.0)[a]	18.3 (14.3)[a]	<.001
6 mo	3.3 (4.8)[a]	10.1 (9.3)[a]	.001
Total score			
Baseline	0.8 (1.9)	0.9 (2.1)	.72
1 wk	24.8 (15.4)[a]	34.4 (17.9)[a]	.04
2 wk	15.6 (10.6)[a]	31.6 (18.6)[a]	<.001
1 mo	9.6 (7.0)[a]	24.8 (16.3)[a]	<.001
6 mo	5.7 (6.5)[a]	11.7 (9.3)[a]	.006
Surgical complications, No. (%)			
Seroma	5 (17.9)	4 (14.3)	.69
Hematoma	1 (3.6)	2 (7.1)	
Axillary web syndrome	0	1 (3.6)	
Lymphedema, No. (%)			
Within 30 d after surgery	1 (3.6)	1 (3.6)	1.00
After 1 mo and within 6 mo after surgery	1 (3.6)	1 (3.6)	1.00
Drainage, No. (%)			
Removal drainage day			
No drainage	4 (14.3)	3 (10.7)	.98
Discharge day	4 (14.3)	3 (10.7)	
First outpatient visit	10 (35.7)	12 (42.9)	
Second outpatient visit	8 (28.6)	8 (28.6)	
Third outpatient visit	2 (7.1)	2 (7.1)	
Total drainage volume, cc	38.9 (37.9)	44.0 (64.3)	.76

[a] Represented paired *t* test (Bonferroni adjusted) $P < .001$ vs baseline.

Our intervention included only 4 supervised exercise sessions during patients' visits to their surgeon, complemented by home-based exercises on all other days. This hybrid approach with video and smartphone assistance could be more cost-effective and less labor intensive. Although many patients with breast cancer experience shoulder dysfunction, most surgeons and medical personnel have assumed that shoulder dysfunction after breast cancer surgery is a common and inevitable part of the healing process.[8,9,17,43] Only patients with breast cancer who experience substantial shoulder dysfunction are referred to physiatrists or physiotherapists, and these referrals most often happen several months to years after breast cancer surgery. Of note, we observed a significant reduction in ROM and strength on the unaffected side in patients in the usual care group. There was a 18% reduction in shoulder strength on the unaffected side within the usual care group at 6 months postsurgery, and this finding is consistent with our previous research.[9] In contrast, the exercise intervention led to a significant improvement in shoulder strength of unaffected side, increasing by up to 44.8% compared to presurgery levels. In comparison, the usual care group experienced a decline in shoulder strength by 17.5% from presurgery levels (eTable 7 in Supplement 2).

In our study, the exercise group showed a significant increase in total physical activity from baseline to 6 months after surgery. These changes in physical activity patterns may be related to relatively small but statistically significant changes in muscle mass in the exercise group from baseline to 6 months after surgery. Both physical activity and muscle mass are associated with the prognosis of breast cancer.[44,45] These results concur with our previous study in which we monitored 70 patients with breast cancer for 6 months[9] and reported a significant reduction in muscle mass and an increase in fat mass at 6 months when there was no exercise intervention. Many pa-

Table 3. Effects of Exercise on Body Composition, Physical Activity, and Quality of Life in Patients With Breast Cancer

Variable	Exercise (n = 28), mean (SD)			Usual care (n = 28), mean (SD)			*P* (group × time)	*P* value (baseline to 1 mo)[a]	*P* value (baseline to 6 mo)[a]
	Baseline	1 mo	6 mo	Baseline	1 mo	6 mo			
Body composition, kg									
Weight	57.9 (10.0)	57.6 (9.6)	57.1 (9.4)	60.4 (9.9)	59.6 (9.7)[b]	59.2 (9.9)	.66	.16	.83
Muscle mass	21.2 (2.9)	20.9 (2.8)[b]	20.7 (2.9)[c]	22.8 (3.1)	21.5 (2.6)[c]	21.4 (2.3)[c]	.02	.08	.67
Fat mass	18.5 (6.7)	18.6 (6.6)	18.6 (6.1)	18.3 (6.8)	19.5 (6.5)[b]	19.3 (7.3)	.35	.06	.79
Physical activity, min/wk									
Vigorous	0	0	0	0	0	0	NA	NA	NA
Moderate	10.7 (42.6)	15.3 (32.8)	62.1 (134.5)	24.3 (61.1)	7.1 (37.8)	1.1 (5.7)	.01	.11	.05
Walking	245.7 (201.9)	333.6 (213.5)	321.1 (242.0)	212.0 (230.3)	202.1 (175.6)	191.1 (118.1)	.18	.09	.98
Total activity	256.4 (199.8)	348.8 (209.2)[b]	383.2 (248.3)[b]	236.2 (255.3)	209.3 (204.3)	192.1 (118.1)	.04	.04	.40
Sedentary	514.4 (149.8)	378.6 (132.0)[c]	364.9 (135.0)[c]	509.2 (154.2)	581.7 (211.0)	535.4 (169.5)	<.001	<.001	.42
EQ-5D									
QoL index	0.84 (0.09)	0.73 (0.11)[b]	0.81 (0.12)	0.84 (0.11)	0.63 (0.06)[c]	0.73 (0.12)[c]	.03	.006	.48
VAS	72.9 (18.8)	81.8 (15.2)	84.1 (12.6)[b]	75.4 (13.7)	70.9 (21.0)	80.7 (12.0)	.01	.009	.04

Abbreviations: EQ-5D, EuroQol 5-Dimension questionnaire; NA, not applicable; QoL, quality of life; VAS, visual analog scale.

[a] Independent *t* test analysis of the mean difference from baseline to 1 month and 6 months after surgery. Represented paired *t* test (Bonferroni corrected).

[b] $P < .025$ vs baseline.

[c] $P < .001$ vs baseline.

tients with breast cancer who receive chemoradiation therapy experienced changes in body composition.[46-48] Our intervention led to minimal changes in body composition in the exercise group despite no additional intervention after 1 month.

Based on our findings, we can speculate that providing exercise rehabilitation would reduce medical expenses and lower the economic burden on the health care system.[41,49] One previous study reported that implementing an exercise program resulted in lowered expenses for patients with cancer by an average of £387.[41] Faster recovery after surgery may also facilitate return to work.[50]

Strengths and Limitations

Our study has several strengths worth noting. One important strength is the development of an evidence-based exercise program comprising 10 steps for early mobilization following breast cancer surgery. This program's formulation involved an exhaustive process, including a systematic review, surgical observation, a prospective study assessing changes in shoulder function postsurgery, expert panel discussions, feasibility testing, and pilot trials. Second, as a strategic measure to improve study efficiency, we collaborated with breast cancer surgeons to meticulously design and validate minimal-intervention strategies. This strategy, comprising 4 supervised sessions, adopts a labor-efficient approach using video resources. Other strengths include the randomized trial design, high adherence to the intervention, and minimal loss to follow-up.

Patients were recruited from a single center, which is a key limitation of our study. While were adequately powered to detect differences, our sample size was relatively small. Therefore, caution should be exercised when generalizing our findings to a broader population and other medical centers. Furthermore, participants in the usual care group at our institution did not receive any in-person postoperative exercise education. Therefore, our results should be interpreted carefully in settings where postoperative exercise or physiotherapy is routinely provided. Muscle strength was measured using a handheld dynamometer by unblinded testers, and their experience and expertise may have influenced patient effort. While efforts were made to standardize testing, there remains a potential for bias. It is important to note that intertester variability was found to be less than 5%.

Conclusions

In conclusion, our data demonstrated improvement in shoulder function and other health parameters with the early intervention tailored exercise programming immediately after surgery for breast cancer. In the future, multicenter and multinational trials should be performed to test the external validity of the combined supervised and home-based exercise program we developed and implemented in this study.

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REFERENCES

1. Moo TA, Sanford R, Dang C, Morrow M. Overview of breast cancer therapy. *PET Clin*. 2018;13(3):339-354. doi:10.1016/j.cpet.2018.02.006

2. Kummerow KL, Du L, Penson DF, Shyr Y, Hooks MA. Nationwide trends in mastectomy for early-stage breast cancer. *JAMA Surg*. 2015;150(1):9-16. doi:10.1001/jamasurg.2014.2895

3. Maajani K, Jalali A, Alipour S, Khodadost M, Tohidinik HR, Yazdani K. The global and regional survival rate of women with breast cancer: a systematic review and meta-analysis. *Clin Breast Cancer*. 2019;19(3):165-177. doi:10.1016/j.clbc.2019.01.006

4. Hayes SC, Johansson K, Stout NL, et al. Upper-body morbidity after breast cancer: incidence and evidence for evaluation, prevention, and management within a prospective surveillance model of care. *Cancer*. 2012;118(8)(suppl):2237-2249. doi:10.1002/cncr.27467

5. Engel J, Kerr J, Schlesinger-Raab A, Sauer H, Hölzel D. Axilla surgery severely affects quality of life: results of a 5-year prospective study in breast cancer patients. *Breast Cancer Res Treat*. 2003;79(1):47-57. doi:10.1023/A:1023330206021

6. McCredie MR, Dite GS, Porter L, et al. Prevalence of self-reported arm morbidity following treatment for breast cancer in the Australian Breast Cancer Family Study. *Breast*. 2001;10(6):515-522. doi:10.1054/brst.2000.0291

7. Torres Lacomba M, Mayoral Del Moral O, Coperias Zazo JL, Yuste Sánchez MJ, Ferrandez JC, Zapico Goñi A. Axillary web syndrome after axillary dissection in breast cancer: a prospective study. *Breast Cancer Res Treat*. 2009;117(3):625-630. doi:10.1007/s10549-009-0371-8

8. Lovelace DL, McDaniel LR, Golden D. Long-term effects of breast cancer surgery, treatment, and survivor care. *J Midwifery Womens Health*. 2019;64(6):713-724. doi:10.1111/jmwh.13012

9. Min J, Yeon S, Ryu J, et al. Shoulder function and health outcomes in newly diagnosed breast cancer patients receiving surgery: a prospective study. *Clin Breast Cancer*. 2023;23(4):e247-e258. doi:10.1016/j.clbc.2023.03.001

10. Gonzalez EA, Saltzstein EC, Riedner CS, Nelson BK. Seroma formation following breast cancer surgery. *Breast J*. 2003;9(5):385-388. doi:10.1046/j.1524-4741.2003.09504.x

11. Gerber LH, Stout N, McGarvey C, et al. Factors predicting clinically significant fatigue in women following treatment for primary breast cancer. *Support Care Cancer*. 2011;19(10):1581-1591. doi:10.1007/s00520-010-0986-7

12. Rebegea L, Firescu D, Dumitru M, Anghel R. The incidence and risk factors for occurrence of arm lymphedema after treatment of breast cancer. *Chirurgia (Bucur)*. 2015;110(1):33-37.

13. Nowicki A, Licznerska B, Rhone P. Evaluation of the quality of life of women treated due to breast cancer using amputation or breast conserving surgery in the early postoperative period. *Pol Przegl Chir*. 2015;87(4):174-180. doi:10.1515/pjs-2015-0040

14. Rietman JS, Dijkstra PU, Hoekstra HJ, et al. Late morbidity after treatment of breast cancer in relation to daily activities and quality of life: a systematic review. *Eur J Surg Oncol*. 2003;29(3):229-238. doi:10.1053/ejso.2002.1403

15. Ganz PA, Guadagnoli E, Landrum MB, Lash TL, Rakowski W, Silliman RA. Breast cancer in older women: quality of life and psychosocial adjustment in the 15 months after diagnosis. *J Clin Oncol*. 2003;21(21):4027-4033. doi:10.1200/JCO.2003.08.097

16. Tevis SE, Steiman JG, Neuman HB, Greenberg CC, Wilke LG. Postoperative complications in combined gynecologic, plastic, and breast surgery: An analysis from National Surgical Quality Improvement Program. *Breast J*. 2019;25(6):1111-1116. doi:10.1111/tbj.13429

17. Chan DN, Lui LY, So WK. Effectiveness of exercise programmes on shoulder mobility and lymphoedema after axillary lymph node dissection for breast cancer: systematic review. *J Adv Nurs*. 2010;66(9):1902-1914. doi:10.1111/j.1365-2648.2010.05374.x

18. Wilson DJ. Exercise for the patient after breast cancer surgery. *Semin Oncol Nurs*. 2017;33(1):98-105. doi:10.1016/j.soncn.2016.11.010

19. Schmitz KH, Ahmed RL, Troxel A, et al. Weight lifting in women with breast-cancer-related lymphedema. *N Engl J Med*. 2009;361(7):664-673. doi:10.1056/NEJMoa0810118

20. Paskett ED, Le-Rademacher J, Oliveri JM, et al. A randomized study to prevent lymphedema in women treated for breast cancer: CALGB 70305 (alliance). *Cancer*. 2021;127(2):291-299. doi:10.1002/cncr.33183

21. Casla S, Hojman P, Márquez-Rodas I, et al. Running away from side effects: physical exercise as a complementary intervention for breast cancer patients. *Clin Transl Oncol*. 2015;17(3):180-196. doi:10.1007/s12094-014-1184-8

22. Kilgour RD, Jones DH, Keyserlingk JR. Effectiveness of a self-administered, home-based exercise rehabilitation program for women following a modified radical mastectomy and axillary node dissection: a preliminary study. *Breast Cancer Res Treat*. 2008;109(2):285-295. doi:10.1007/s10549-007-9649-x

23. Bendz I, Fagevik Olsén M. Evaluation of immediate versus delayed shoulder exercises after breast cancer surgery including lymph node dissection—a randomised controlled trial. *Breast*. 2002;11(3):241-248. doi:10.1054/brst.2001.0412

24. Ochalek K, Gradalski T, Partsch H. Preventing early postoperative arm swelling and lymphedema manifestation by compression sleeves after axillary lymph node interventions in breast cancer patients: a randomized controlled trial. *J Pain Symptom Manage*. 2017;54(3):346-354. doi:10.1016/j.jpainsymman.2017.04.014

25. Ammitzbøll G, Kristina Kjær T, Johansen C, et al. Effect of progressive resistance training on health-related quality of life in the first year after breast cancer surgery—results from a randomized controlled trial. *Acta Oncol*. 2019;58(5):665-672. doi:10.1080/0284186X.2018.1563718

26. Oliveira MMF, Gurgel MSC, Amorim BJ, et al. Long term effects of manual lymphatic drainage and active exercises on physical morbidities, lymphoscintigraphy parameters and lymphedema formation in patients operated due to breast cancer: a clinical trial. *PLoS One*. 2018;13(1):e0189176. doi:10.1371/journal.pone.0189176

27. Freire de Oliveira MM, Costa Gurgel MS, Pace do Amaral MT, et al. Manual lymphatic drainage and active exercise effects on lymphatic function do not translate into morbidities in women who underwent breast cancer surgery. *Arch Phys Med Rehabil*. 2017;98(2):256-263. doi:10.1016/j.apmr.2016.06.024

28. Petito EL, Esteves MT, Elias S, Facina G, Nazário AC, Gutiérrez MG. The influence of the initiation of an exercise programme on seroma formation and dehiscence following breast cancer surgery. *J Clin Nurs*. 2014;23(21-22):3087-3094. doi:10.1111/jocn.12544

29. Dönmez AA, Kapucu S. The effectiveness of a clinical and home-based physical activity program and simple lymphatic drainage in the prevention of breast cancer-related lymphedema: a prospective randomized controlled study. *Eur J Oncol Nurs*. 2017;31:12-21. doi:10.1016/j.ejon.2017.09.004

30. Ammitzbøll G, Johansen C, Lanng C, et al. Progressive resistance training to prevent arm lymphedema in the first year after breast cancer surgery: results of a randomized controlled trial. *Cancer*. 2019;125(10):1683-1692. doi:10.1002/cncr.31962

31. Cho Y, Do J, Jung S, Kwon O, Jeon JY. Effects of a physical therapy program combined with manual lymphatic drainage on shoulder function, quality of life, lymphedema incidence, and pain in breast cancer patients with axillary web syndrome following axillary dissection. *Support Care Cancer*. 2016;24(5):2047-2057. doi:10.1007/s00520-015-3005-1

32. de Rezende LF, Franco RL, de Rezende MF, Beletti PO, Morais SS, Gurgel MSC. Two exercise schemes in postoperative breast cancer: comparison of effects on shoulder movement and

lymphatic disturbance. *Tumori*. 2006;92(1):55-61. doi:10.1177/030089160609200109

33. Kilbreath SL, Refshauge KM, Beith JM, Ward LC, Simpson JM, Hansen RD. Progressive resistance training and stretching following surgery for breast cancer: study protocol for a randomised controlled trial. *BMC Cancer*. 2006;6:273. doi:10.1186/1471-2407-6-273

34. Shu Q, Yang Y, Shao Y, et al. Comparison of rehabilitation training at different timepoints to restore shoulder function in patients with breast cancer after lymph node dissection: a randomized controlled trial. *Arch Phys Med Rehabil*. 2023;104(5):728-737. doi:10.1016/j.apmr.2023.01.021

35. Norkin CC, White DJ. *Measurement of Joint Motion: A Guide to Goniometry*. FA Davis; 2016.

36. Bohannon RW, Andrews AW. Interrater reliability of hand-held dynamometry. *Phys Ther*. 1987;67(6):931-933. doi:10.1093/ptj/67.6.931

37. Choi Y, Park JW, Noh S, Kim MS, Park YH, Sun DH. Reliability, validity, and responsiveness of the Korean version of the Shoulder Disability Questionnaire and Shoulder Rating Questionnaire. *Ann Rehabil Med*. 2015;39(5):705-717. doi:10.5535/arm.2015.39.5.705 doi:10.5535/arm.2015.39.5.705

38. Lee J, Lee C, Min J, et al. Development of the Korean Global Physical Activity Questionnaire: reliability and validity study. *Glob Health Promot*. 2020;27(3):44-55. doi:10.1177/1757975919854301

39. Kim SH, Ahn J, Ock M, et al. The EQ-5D-5L valuation study in Korea. *Qual Life Res*. 2016;25(7):1845-1852. doi:10.1007/s11136-015-1205-2

40. Kim M, Lee M, Kim M, Oh S, Jung S, Yoon B. Effectiveness of therapeutic inflatable ball self-exercises for improving shoulder function and quality of life in breast cancer survivors after sentinel lymph node dissection. *Support Care Cancer*. 2019;27(7):2349-2360. doi:10.1007/s00520-019-4656-0

41. Bruce J, Mazuquin B, Canaway A, et al; Prevention of Shoulder Problems Trial (PROSPER) Study Group. Exercise versus usual care after non-reconstructive breast cancer surgery (UK PROSPER): multicentre randomised controlled trial and economic evaluation. *BMJ*. 2021;375:e066542. doi:10.1136/bmj-2021-066542

42. Spei ME, Samoli E, Bravi F, La Vecchia C, Bamia C, Benetou V. Physical activity in breast cancer survivors: A systematic review and meta-analysis on overall and breast cancer survival. *Breast*. 2019;44:144-152. doi:10.1016/j.breast.2019.02.001

43. Al-Hilli Z, Wilkerson A. Breast surgery: management of postoperative complications following operations for breast cancer. *Surg Clin North Am*. 2021;101(5):845-863. doi:10.1016/j.suc.2021.06.014

44. Aleixo GFP, Williams GR, Nyrop KA, Muss HB, Shachar SS. Muscle composition and outcomes in patients with breast cancer: meta-analysis and systematic review. *Breast Cancer Res Treat*. 2019;177(3):569-579. doi:10.1007/s10549-019-05352-3

45. Redemski T, Hamilton DG, Schuler S, Liang R, Michaleff ZA. Rehabilitation for women undergoing breast cancer surgery: a systematic review and meta-analysis of the effectiveness of early, unrestricted exercise programs on upper limb function. *Clin Breast Cancer*. 2022;22(7):650-665. doi:10.1016/j.clbc.2022.06.001

46. Jang MK, Park S, Park C, Doorenbos AZ, Go J, Kim S. Body composition change during neoadjuvant chemotherapy for breast cancer. *Front Oncol*. 2022;12:941496. doi:10.3389/fonc.2022.941496 doi:10.3389/fonc.2022.941496

47. van den Berg MM, Winkels RM, de Kruif JT, et al. Weight change during chemotherapy in breast cancer patients: a meta-analysis. *BMC Cancer*. 2017;17(1):259. doi:10.1186/s12885-017-3242-4

48. Pedersen B, Delmar C, Lorincz T, Falkmer U, Gronkjaer M. Investigating changes in weight and body composition among women in adjuvant treatment for breast cancer: a scoping review. *Cancer Nurs*. 2019;42(2):91-105. doi:10.1097/NCC.0000000000000590

49. Wonders KY, Schmitz K, Wise R, Hale R. Cost-savings analysis of an individualized exercise oncology program in early-stage breast cancer survivors: a randomized clinical control trial. *JCO Oncol Pract*. 2022;18(7):e1170-e1180. doi:10.1200/OP.21.00690

50. Islam T, Dahlui M, Majid HA, et al. Factors associated with return to work of breast cancer survivors: a systematic review. *BMC Public Health*. 2014;14(Suppl 3):S8. doi:10.1186/1471-2458-14-S3-S8