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Does Yoga Therapy Improve Range of Motion in Shoulders of Women Recovering from Breast Cancer Surgery? A Randomised Controlled Trial

Wendy Wing Tak Lam[1,2*], Danielle Wing Lam Ng[1,2], Richard Fielding[1,2], Daniel Yee Tak Fong[3], Ava Kwong[4], Inda Soong[5], Wendy Wing Lok Chan[6], Vanessa Oi Kwan Chun[7] and Sara Fung[7]

Abstract

Background Upper limb impairment is common among women receiving breast cancer treatment. Although yoga is popular and accessible in cancer support communities, its impact on upper limb function in these women is not well understood. This randomized controlled trial investigated the effects of yoga on shoulder range of motion in women recovering from breast cancer surgery. Eligible participants were Chinese women with early-stage breast cancer who had recently completed surgery and adjuvant treatment. Following the baseline assessment, they were randomly assigned (1:1:1) to a 12-week yoga intervention, a 12-week relaxation intervention (active control), or a postoperative exercise DVD (passive control). Primary outcomes measured shoulder rotation flexibility and range of motion. Secondary outcomes included health-related quality of life, fatigue, pain, sleep quality, anxiety, and depression. All outcomes were assessed at baseline, immediately post-intervention, and at 3, 6, and 12 months post-intervention.

Results Out of 760 potential participants, 444 were enrolled and randomly assigned to yoga intervention ($n=148$), active control ($n=148$), or passive control ($n=148$). Linear Mixed Modelling indicated that, compared to the Passive control group, the Yoga group showed significant improvement in shoulder rotation flexibility scores ($p=0.004$) and right hand up back scratch test scores ($p=0.013$) at all time points. There was no significant difference in the back scratch test scores for the left hand up between groups. Secondary outcomes did not significantly differ among the study groups.

Conclusions Study findings suggest that yoga intervention can improve upper-extremity mobility in women with breast cancer.

Trial Registration: HKU Clinical Trials Registry, HKUCTR-1600. Registered 25 May 2013, https://www.hkuctr.com/Study/Show/36d8e3e8d051473b9c2e69bc8ee35dd1.

Keywords Cancer survivorship, Yoga therapy, Breast cancer, Upper limb function, Randomised controlled trial

*Correspondence:
Wendy Wing Tak Lam
wwtlam@hku.hk

Full list of author information is available at the end of the article

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Background

Breast cancer is the most common cancer worldwide, with more than 2.26 million new cases of breast cancer in women reported in 2020 [1]. Most women diagnosed with early stage breast cancer undergo surgery and expect disease-free recovery. However, the multiple physical and psychosocial sequelae of breast cancer diagnosis and treatment often have profound consequences for the affected women [2–5], generating significant physical and psychological distress.

The tightness of scarring tissues on the upper chest wall and limitations to the range of motion of the shoulder joints are two of the most common residual symptoms arising from breast cancer surgery. In addition to the physical restrictions on women's movements, these symptoms seem to be linked to affective symptoms, including anxiety and depression [3]. Owing to the nature of breast cancer treatments, including surgery and radiation therapy, upper limb impairment is commonly reported in affected women [6], with 50% of screened breast cancer patients having chronic arm morbidity [7]. Limited range of arm/shoulder motion (ROM) affects between 24 and 53% of patients [8]. Patients with chronic arm morbidity may be more likely to report a poor quality of life [7, 9].

Meta-analysis studies of exercise interventions, mostly involving supervised stretching and strengthening arm exercises, to improve upper limb function in women following breast cancer treatments, concluded that structured exercise programs in the postoperative period significantly improved shoulder ROM [9, 10]. Hatha yoga, a popular mind-body intervention in women with breast cancer, combines physical postures involving stretching and strengthening exercises to improve flexibility, strength and stamina along with breathing exercises, meditation, and relaxation. However, most studies on the effects of yoga have focused on health-related quality of life [10–12], psychosomatic symptoms, such as fatigue and sleep [13–15], and mental well-being [11, 12]. Few studies have examined the effect of yoga exercise on improving upper limb function in women with breast cancer, and those that have mostly focused on breast cancer-related lymphoedema [16–19]. Furthermore, currently available evidence is mainly derived from trials involving a modest number of participants. Given the popularity of yoga exercise among cancer survivors and its wide availability in the cancer support community, hatha yoga exercises are potentially an alternative intervention for improving upper extremity function if it is beneficial. However, this is yet to be tested.

Also, yoga interventions typically include a variety of yoga practices. For example, a yoga class may include 30–40 min of gentle stretching poses, 10–15 min of breathing exercise, 20–30 min of meditation and 5–10 min of final relaxation. It is unclear which elements of yoga programmes produce the beneficial effects. For instance, breathing exercises and relaxation itself can help reduce muscle tension and pain, thereby enabling patients to extend their ROM more effectively [20]. Currently, no study has compared the effect of yoga exercise intervention with breathing exercise and relaxation interventions on shoulder ROM among women with breast cancer surgery.

This randomized controlled trial aimed to examine the effects of yoga exercise on shoulder ROM in women recovering from breast cancer surgery. We tested a 12-week yoga exercise intervention compared with two control groups: an active control involving a 12-week breathing exercise and relaxation intervention, and a passive control condition involving a video demonstrating standard hospital-recommended postoperative exercises after primary treatment for curative breast cancer. The primary outcome was shoulder ROM, with secondary outcomes of cancer-specific quality of life, breast symptoms, sleep quality, pain, fatigue, anxiety, and depression immediately post-intervention as well as at 3, 6, and 12-month post-intervention. We hypothesized that compared with participants in the active control or passive control groups, participants in the yoga group would have greater improvement in shoulder ROM, greater reduction in breast symptoms, pain, fatigue, anxiety, and depression, and greater improvements in cancer-specific quality of life.

Methods

Study Design and Participants

This was a randomized three-group parallel, controlled trial (RCT) with the allocation of patients to either yoga (intervention), relaxation (active control), or usual care (passive control) groups (1:1:1). This study was conducted at two breast centres and two clinical oncology departments in Hong Kong Government-funded hospitals between 2013 and 2019. The inclusion criteria were female Cantonese-speaking Chinese patients diagnosed with early stage breast cancer who completed primary treatment (surgery plus adjuvant chemotherapy and/or radiation therapy) within 9 months. Patients were deemed ineligible if they were diagnosed with locoregional metastasis, were currently practicing yoga since their diagnosis of breast cancer, or were otherwise physically unable to practice yoga. Random assignment was performed using a prior computer-generated random-number sequence. Each recruiting site used a block randomization with randomized block sizes of 2,4, and 6. Randomization (by a statistician) was performed prior to study recruitment. The serially labelled opaque sealed envelope method was used for randomization. After explanation of the study, participant rights, and

anonymity safeguards, women who agreed to participate completed the written consent, baseline questionnaire, and baseline assessment of shoulder ROM immediately. The research assistant then broke a sealed envelope for the next eligible patient, indicating whether that woman was to be allocated to yoga, relaxation, or passive control arms. Hence, the allocation was concealed from the research assistant and patients until the completion of the baseline assessment. This study was conducted according to the CONSORT (Consolidated Standards of Reporting Trials) guidelines and study protocol (Appendix 1).

Intervention

The yoga intervention consisted of a standardized 60-minute, once-weekly in-person yoga class, conducted over a duration of 12 weeks. The sessions were delivered in groups of 10–12 participants and were instructed by a certified Hatha yoga instructor. The intervention, designed by a very experienced Hatha yoga practitioner who specialized in yoga therapy for managing various chronic conditions, including cancer rehabilitation, comprised a standard set of yoga postures and breathing exercises (Supplement Table S1). The key goal of the yoga intervention was to improve shoulder ROM and reduce related breast symptoms (scarring tightness). Hence, many postures focused on improving shoulder and upper back flexibility and performing back strengthening exercises. In the yoga sessions, the instructor assisted the participants in achieving proper alignment by adjusting their posture. Each participant was given a DVD demonstrating this yoga sequence to encourage daily home practices throughout the entire study period.

The active control intervention (breathing exercise and relaxation intervention) was also a standardized 60-minutes once weekly class, of 12 weeks duration delivered in groups of 10–12 participants that incorporated breathing exercises and progressive muscle relaxation practice only (Supplement Table S2). The classes were taught by a certified Hatha yoga instructor at a local yoga center. The goal was to learn how to relax the body and improve breathing. As with the Yoga intervention group, active control participants were given a DVD demonstrating only breathing exercises and progressive muscle relaxation practice to encourage daily home practice throughout the study period. Qualified yoga instructors delivered both interventions. All instructors attended a training workshop that specified what exercises to use, in what sequence, and instructors asked to follow this standardized format for both interventions. While no incentive was offered to study participants, we compensated for the transportation cost (a total of 23 US dollars for attending a 12-week once weekly session) for participants allocated to the Yoga intervention or the Breathing exercise and relaxation intervention.

The passive control intervention involved the standard hospital-recommended postoperative exercise protocol, comprising gentle shoulder movement and arm-raising exercises for women following breast cancer surgery. Participants allocated to this passive control intervention were given a DVD demonstrating these postoperative exercise and encouragement to practice at home daily throughout the entire study period. No active teaching was involved for this group.

Measures

The primary outcome was the change in the mean score of the measures of shoulder rotation flexibility assessed using the shoulder circumduction test [21] and shoulder ROM assessed using the back scratch test [22], between baseline and the 3-month post-intervention (short-term effects). We also examined the change in mean scores between baseline and immediate post-intervention, and at 6- and 12th months post intervention to evaluate the long- term effects.

Shoulder rotation flexibility was measured using the shoulder circumduction test [21]. Participants held a flexible strap in front of the body, starting with both hands as wide apart as possible with palms facing downwards, then lifting the strap over the head moving the arms rearwards and down behind the back retaining a hold on the strap with both hands at all times. Participants were directed to perform this exercise while keeping both arms straight and fully extended. If successful, the hands were moved closer together and the movement was repeated, until the movement could not be completed with straight arms. To assess flexibility, the best score of three trials was recorded. The score is the angle of fanning out, in degrees, calculated using the formula S/2L, where S = how much the strap shifted in cm during the movement and L = length of arm in cm from the acromion to the metacarpophalangeal joint of the middle finger [21]. A higher score indicates better shoulder flexibility. The measurements were performed by a trained research assistant. The shoulder circumduction test has good internal consistency for assessing shoulder rotation flexibility in adults aged >55 years [21].

Shoulder ROM was assessed using the back scratch test [22] (Fig. 1). This test was performed in the standing position. Participants were asked to place one hand behind the head and back over the shoulder, then reach as far as possible down the middle of the back, with the palm touching the spine and the fingers directed downwards. Then, place the other arm behind the back, palm facing outward, and fingers upward, and reach up as far as possible, attempting to touch, overlap the middle fingers of both hands. A trained research assistant

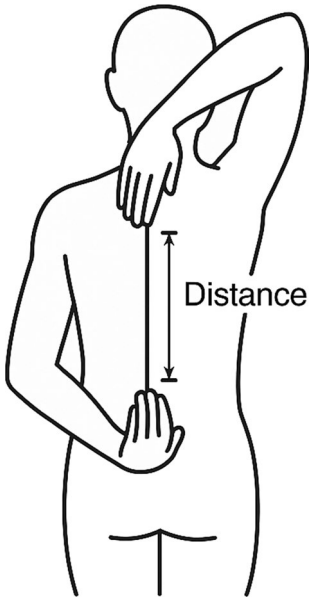

Fig. 1 Back Scatch test

measured the distance between the tips of the middle fingers to assess the range of motion. If the fingertips touch, the score is zero. If they did not touch, the distance between the fingertips was measured as a negative score. If they overlapped, this was measured with a positive score. We performed three trials on each side and used the best score for each side. Higher scores indicate better shoulder ROM. The back stretch test demonstrates good intraclass reliability and criterion validity for assessing upper-body flexibility in community-dwelling older adults [22]. For female age 65–69, scores < -3.5 inches (< – 8.89 cm) is considered as below average, -3.5 to 1.5 inches (– 8.89 to 3.81 cm) as normal, >1.5 inches (3.81 cm) as above average [22].

Secondary outcomes included the change in the mean score of the measure of cancer-specific quality of life, breast symptoms, sleep quality, pain, fatigue, anxiety, and depression between baseline and immediately post-intervention as well as at 3, 6, and 12-month post-intervention. To measure cancer-specific quality of life (QoL), the 30-items standard Chinese version of the EORTC General Quality of Life Questionnaire (QLQ-C30) with five functional scales (physical, role, emotional, cognitive, and social) was used [23]. All five function scales range from 0 to 100, with higher scores representing higher levels of functioning. Breast and arm symptoms were measured using two subscales of the EORTC QLQ Breast Cancer Module, with scores ranging from 0 to 100 [24]. A high score on the symptom scale represents a high level of symptoms. The 19-item Chinese version of the Pittsburgh Sleep Quality Index (PSQI) [25] was used to measure sleep quality. The PSQI has seven component scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction [26]. Each component is scored from 0 to 3, with a global score ranging from 0 to 21. Higher scores indicate greater sleep disturbances. The 7-item Chinese version of the Chronic Pain Grade Scale was used to measure pain intensity (3 items) and pain-related disability (4 items) using an 11-point rating scale (0 to 10) [27, 28]. To calculate each pain scale, the average scores of the corresponding items were multiplied by 10, yielding possible scores ranging from 0 to 100. Higher scores indicated greater pain intensity and disability. The 11-item Chinese version of the Chalder Fatigue Scale was used to measure physical fatigue (7 items) and mental fatigue (4 items) [29, 30]. Each item was rated on a four-point Likert scale, and each subscale score was obtained by summing all relevant items. Higher scores indicated greater fatigue. The 14-item Chinese version of the Hospital Anxiety and Depression Scale (HADS) comprises two subscales that measure anxiety and depression [31]. Possible subscale scores ranged from 0 to 21, with higher scores indicating greater anxiety and depression symptoms, respectively.

Statistical Analyses

Descriptive statistics were compared between the yoga intervention, and active and passive control groups at baseline. The intention-to-treat analysis was performed for all participants with baseline outcome measures. Linear mixed-effects models (LLM) were used to estimate the effect of the intervention on primary and secondary outcome measures, accounting for repeated measures. For each outcome, the LLM included the main and interaction effects of the intervention group and time (baseline, immediate post-intervention, 3-month, 6-month and 12-month post-interventions). No differences were assumed between the groups at baseline. With the multiple primary outcomes used in the study, Bonferroni correction was applied for the primary outcome analysis. Adjusted for the primary outcomes, the Bonferroni-adjusted p-value was 0.017 (0.05/3). All secondary outcome analyses were used the standard a level of 0.05. Sensitivity analysis was conducted by adjusting for baseline covariates that were significantly correlated with primary outcome measures. Statistical analyses were performed using SPSS software (IBM SPSS Statistics version 27). Bias corrected Hedge's g was calculated to assess the effect size [32]. Hedge's g effect sizes of 0.2, 0.5, and 0.8 defined as small, medium, and large effects, respectively [32].

The sample size was calculated to detect a 0.29 (based on the conservative assumption of a small effect size) in shoulder ROM circumduction, with a two-sided a of 0.05 and power 80%. Recruitment of 148 patients per group was planned.

Results

Between 14th May, 2013 and 25th November, 2017, 760 patients were identified, of which 648 met the eligibility criteria. Of the 648 patients, 204 refused to participate (Fig. 2). The remaining 444 patients were randomly assigned according to the block randomization: 148 to receive Yoga intervention, 148 to receive Active control, and 148 to receive Passive control. There were no significant differences between the groups in terms of demographic or clinical characteristics (Table 1) or baseline outcome measures (Tables 2 and 3). In the Yoga therapy and Active control groups, 21% and 12% completed all 12

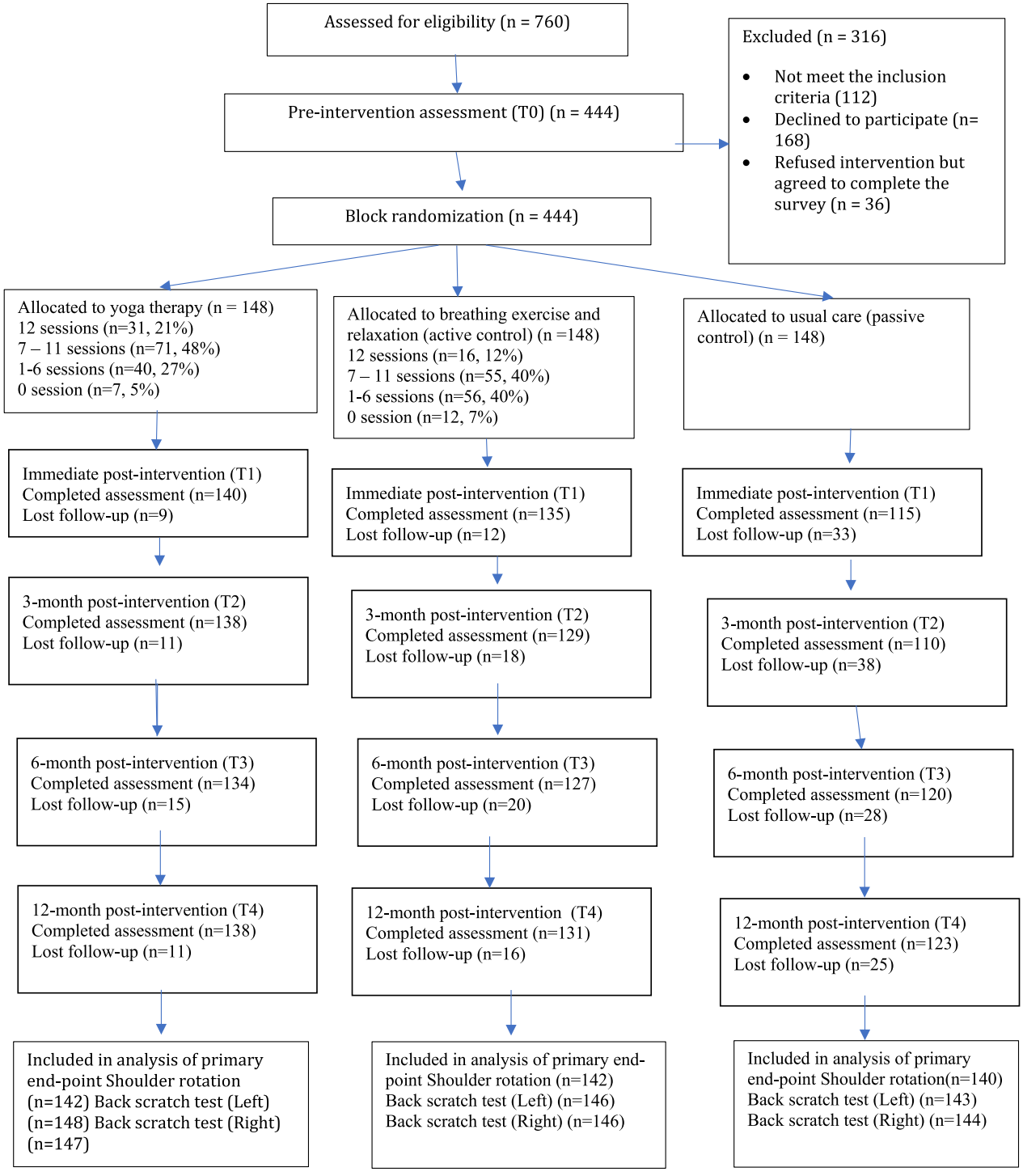

Fig. 2 CONSORT Diagram

Table 1 Patient demographic and clinical characteristics

	Yoga therapy group (*N*=148)	**Breathing exercise and Relaxation group (*N*=148)**	**Passive control (*N*=148)**
Age (years)	51.2 (SD 9.1)	51.3 (8.8)	51.7 (SD 9.1)
Martial status			
Married	105 (70.5%)	106 (72.1%)	100 (67.9%)
Single	31 (20.8%)	20 (13.6%)	31 (20.9%)
Divorced	10 (6.7%)	14 (9.5%)	12 (8.1%)
Widowed	3(12.0%)	7 (4.8%)	5 (3.4%)
Education level			
No formal education	4 (2.7%)	1 (0.7%)	2 (1.4%)
Primary	16 (10.7%)	10 (6.8%)	13 (8.8%)
Secondary	84 (56.4%)	84 (57.1%)	79 (53.4%)
Tertiary	45 (30.2%)	52 (35.4%)	54 (36.5%)
Occupation			
Employed	67 (45%)	87 (59.2%)	76 (51.4%)
Retired	19 (12.8%)	16 (10.9%)	16 (10.8%)
Housewife	19 (12.8%)	22 (15.0%)	20 (13.5%)
Unemployed	44 (29.5%)	22 (15.0%)	36 (24.3%)
Monthly household income (HK$)			
≤ 10,000	22 (15.1%)	19 (13.3%)	16 (11.3%)
10,001-20,000	25 (17.1%)	18 (12.6%)	27 (19.1%)
20,001-30,000	27 (18.5%)	26 (18.2%)	37 (26.2%)
30,001-40,000	28 (19.2%)	26 (18.2%)	17 (12.1%)
>40,000	44 (30.1%)	54 (37.8%)	44 (31.2%)
Time since diagnosis (months)	8.72 (3.82)	8.72 (3.16)	8.32 (2.90)
Stage of disease			
Stage 0/I	36 (24.2%)	46 (31.3%)	34 (23.1%)
Stage II	79 (53.0%)	67 (45.6%)	74 (50.3%)
Stage III	34 (22.8%)	34 (23.1%)	39 (26.5%)
Type of surgery			
Breast conserving surgery	53 (35.6%)	68 (46.3%)	55 (37.2%)
Mastectomy	80 (53.7%)	62 (42.2%)	70 (47.3%)
Mastectomy plus immediate reconstruction	16 (10.7%)	17 (11.6%)	23 (15.5%)
Surgical side			
Right side	78 (53.1%)	65 (46.4%)	71 (52.2%)
Left side	63 (42.9%)	68 (48.6%)	56 (41.2%)
Both sides	6 (4.0%)	7 (5.0%)	9 (6.6%)
Previous radiation therapy (Yes)	113 (75.8%%)	116 (78.9%)	117 (79.1%)
Previous Herceptin therapy (Yes)	47 (31.5%)	48 (32.7%)	48 (32.4%)
Current hormonal therapy at baseline (Yes)	98 (77.2%)	99 (81.8%)	111 (84.7%
Frequency practicing the assigned activity			
At immediate post-intervention*	Daily (12%) Several times a week (48%) Once a week (18%) Few times a month (12%) Seldom to Not at all (10%)	Daily (18%) Several times a week (33%) Once a week (13%) Few times a month (7%) Seldom to Not at all (30%)	Daily (11%) Several times a week (15%) Once a week (4%) Few times a month (8%) Seldom to Not at all (63%)
At 3-month post-intervention*	Daily (15%) Several times a week (30%) Once a week (16%) Few times a month (17%) Seldom to Not at all (22%)	Daily (23%) Several times a week (19%) Once a week (15%) Few times a month (34%) Seldom to Not at all (29.7%)	Daily (13%) Several times a week (7.3%) Once a week (6%) Few times a month (8%) Seldom to Not at all (66%)

Table 1 (continued)

	Yoga therapy group (*N*=148)	Breathing exercise and Relaxation group (*N*=148)	Passive control (*N*=148)
At 6-month post-intervention*	Daily (13%) Several times a week (25%) Once a week (18%) Few times a month (15%) Seldom to Not at all (29%)	Daily (12%) Several times a week (13%) Once a week (13%) Few times a month (17%) Seldom to Not at all (46%)	Daily (9%) Several times a week (6%) Once a week (8%) Few times a month (9%) Seldom to Not at all (68%)
At 12-month post-intervention*	Daily (14%) Several times a week (18%) Once a week (16%) Few times a month (12%) Seldom to Not at all (40%)	Daily (12%) Several times a week (13%) Once a week (8%) Few times a month (14%) Seldom to Not at all (53%)	Daily (10%) Several times a week (8%) Once a week (3%) Few times a month (7%) Seldom to Not at all (72%)

*$p \leq 0.001$

sessions, 48% and 40% completed 7 to 11 sessions, 27% and 40% completed 1 to 6 sessions, and 5% and 7% completed zero sessions (Fig. 2). The loss to follow-up ranged from 6% to 22%, with a higher percentage in the Passive control group. Non-attendance was mainly due to participants being unavailable, while the primary reasons for loss to follow-up were the inability to contact participants according to the assessment schedule or their disinterest in completing the assessment. There were no significant baseline differences in demographic, clinical, or primary outcomes between participants who completed and those who did not complete the immediate post-intervention assessment. The participants were asked how frequently they practiced the assigned activity at home. As shown in Table 1, over 50% of the participants assigned to the Yoga intervention or Active control practiced at least once a week for up to 3-month post-intervention, compared to over 60% of Passive control assignees reporting they seldom or never practiced the standard postoperative exercise. For participants in the Yoga intervention or Active control, over 45% and 33%, respectively, continued to practice at least once a week throughout the 12-month intervention. Participants were instructed to notify us of any physical discomfort or injuries experienced while performing the assigned intervention. No adverse effects were reported by any of the study participants.

Primary Outcomes

Compared to patients in the Passive control group, patients in the Yoga group improved significantly more in the scores of shoulder rotation flexibility at all time points ($p = 0.004$): immediately post-intervention (mean difference 3.30 cm, 95% CI 1.11, 5.49, $p = 0.001$), 3-month (mean difference 3.64 cm, 95% CI 1.54, 5.73, $p < 0.001$), 6-month (mean difference 4.23 cm, 95% CI 2.90, 6.38, $p < 0.001$), and 12-month (mean difference 4.23 cm, 95% CI 2.09, 6.38, $p = 0.009$) (Table 2, Supplementary Fig. 1a). Compared to those in the Active control group, participants in the Yoga group demonstrated significantly greater improvement in shoulder rotation flexibility scores at the 3-month follow-up (mean difference 2.34 cm, 95% CI 0.33, 4.35, $p = 0.0016$).

Compared to patients in Passive control group, patients in the Yoga group improved significantly more on the back scratch test scores on the right hand up at all time points ($p = 0.0013$): immediately post-intervention (mean difference 3.77 inches/ 9.58 cm, 95% CI 0.81, 6.73/ 2.06, 17.09 cm, $p = 0.007$), 3-month (mean difference 3.47 inches/ 8.81 cm, 95% CI 0.47, 6.46/ 1.19, 16.41 cm, $p = 0.017$), 6-month (mean difference 3.57 inches/ 9.07 cm, 95% CI 0.56, 6.57/ 1.42, 16.69 cm, $p = 0.014$), and 12-month (mean difference 3.71 inches/ 9.42 cm, 95% CI 0.72, 6.71/ 1.83, 17.05 cm, $p = 0.009$) (Table 2, Supplementary Fig. 1b). No significant difference was observed between Yoga and Active control groups.

No significant difference between groups in the back scratch test scores on the left hand up was observed at any time point (Table 2, Supplementary Fig. 1c).

Post-hoc linear mixed-effects growth modeling revealed significant within-group improvements in shoulder range of motion across the full sample, with shoulder circumduction increasing ($\beta = 7.95$, $SE = 1.34$, $p < 0.001$) and both left-hand up ($\beta = 5.99$, $SE = 1.44$, $p < 0.001$) and right-hand up ($\beta = 4.30$, $SE = 1.17$, $p < 0.001$) back-scratch scores improving significantly. Time × group interactions showed that the Yoga group improved significantly faster than the Passive control group on left-hand up back scratch ($\beta = -5.72$, $SE = 2.13$, $p < 0.05$) and right-hand up back scratch ($\beta = -5.40$, $SE = 1.76$, $p < 0.05$), and outpaced both the Breathing & Relaxation ($\beta = -6.87$, $SE = 1.85$, $p < 0.001$) and Passive control ($\beta = -5.37$, $SE = 1.93$, $p < 0.01$) groups in shoulder circumduction gains.

Secondary Outcomes

The secondary outcomes are summarized in Table 3. Except for the EORTC QoL social functioning scores ($p = 0.009$), none of the secondary outcomes differed between groups. Patients in Passive control reported significantly higher social functioning scores at immediate

Table 2 Linear Mixed-Effect model analyses for the primary outcomes

Primary outcomes	Timepoints	Intervention groups			Yoga Vs Breathing exercise and relaxation				Yoga Vs Control				Breathing exercise and relaxation Vs Control			Overall P
		Yoga	Breathing exercise and relaxation	Control	Estimate for Difference	95% CI	P	Hedge's g	Estimate for Difference	95% CI	P	Hedge's g	Estimate for Difference	95% CI	P	
		(*n*=142)	(*n*=142)	(*n*=140)												
		Mean (SD)	Mean (SD)	Mean (SD)												
Shoulder Rotation Flexibility (cm) (*n*=424)	Baseline	57.67 (7.91)	58.74 (7.91)	57.16 (7.90)	-1.06	-3.32, 0.57	0.76		0.51	-1.75, 2.77	0.99		1.57	-2.77, 1.75	0.28	0.004
	Immediate post-intervention	61.12 (7.40)	59.44 (7.47)	57.82 (7.88)	1.68	-0.44, 3.78	0.17	0.23	3.30	1.11, 5.49	0.001	0.43	1.62	-3.79, 0.44	0.23	
	3-month	61.55 (7.17)	59.63 (7.35)	57.31 (7.78)	2.34	0.33, 4.35	0.016	0.38	3.64	1.54, 5.73	<0.001	0.57	1.3	-0.84, 3.44	0.44	
	6-month	61.87 (7.46)	59.72 (7.48)	58.73 (7.82)	1.92	-0.15, 3.99	0.079		4.23	2.09, 6.38	<0.001	0.41	2.32	0.15, 4.48	0.031	
	12-month	61.78 (8.53)	60.11 (8.65)	58.94 (9.09)	1.06	-1.38, 3.51	0.89		3.14	0.62, 5.66	0.009	0.32	2.08	-0.46, 4.62	0.15	
Back scratch (inches) (Left) (*n*=437)	Baseline	-6.74 (10.99)	-6.05 (10.99)	-6.39 (10.99)	-0.69	-3.77, 2.38	0.99		-0.36	-3.45, 2.73	0.99		0.33	-2.77, 3.44	0.99	0.56
	Immediate post-intervention	-4.11 (11.16)	-5.13 (11.21)	-6.40 (11.54)	1.02	-2.11, 4.14	0.99		2.29	-0.89, 5.49	0.25		1.28	-1.92, 4.49	0.99	
	3-month	-4.05 (11.25)	-5.14 (11.33)	-6.16 (11.76)	1.09	-2.07, 4.34	0.99		2.11	-1.12, 5.34	0.36		1.02	-2.25, 4.28	0.99	
	6-month	-4.37 (11.33)	-5.12 (11.37)	-6.20 (11.71)	0.75	-2.42, 3.92	0.99		1.83	-1.40, 5.08	0.53		1.08	-2.17, 4.34	0.99	
	12-month	-4.22 (11.29)	-4.66 (11.39)	-6.92 (11.62)	0.44	-2.74, 3.61	0.99		2.69	-0.52, 5.92	0.14		2.26	-0.98, 5.50	0.28	

Table 2 (continued)

Primary outcomes	Timepoints	Intervention groups			Yoga Vs Breathing exercise and relaxation				Yoga Vs Control				Breathing exercise and relaxation Vs Control			Over-all P
		Yoga	Breathing exercise and relaxation	Control	Estimate for Difference	95% CI	P	Hedge's g	Estimate for Difference	95% CI	P	Hedge's g	Estimate for Difference	95% CI	P	
		(*n*=142)	(*n*=142)	(*n*=140)												
		Mean (SD)	Mean (SD)	Mean (SD)												
Back scratch (Right) (inches) (*n*=437)	Baseline	-1.03 (10.18)	-2.25 (10.18)	-2.11 (10.18)	1.22	-1.63, 4.07	0.91		1.07	-1.63,4.07	0.99		-0.15	-3.02, 2.72	0.99	0.013
	Immediate post-intervention	1.48 (10.43)	-0.79 (10.39)	-2.29 (10.68)	2.26	-0.63, 5.17	0.18		3.77	0.81, 6.73	0.007	0.36	1.51	-1.46, 4.47	0.67	
	3-month	1.11 (10.40)	-1.17 (10.51)	-2.37 (10.88)	2.27	-0.65, 5.20	0.19		3.47	0.47, 6.46	0.017	0.33	1.19	-1.81, 4.21	0.99	
	6-month	1.04 (10.50)	-1.87 (10.56)	-2.53 (10.87)	2.9	-0.04, 5.85	0.06		3.57	0.56, 6.57	0.014	0.33	0.66	-2.35, 3.67	0.99	
	12-month	1.38 (10.48)	-1.02 (10.57)	-2.33 (10.81)	2.41	-0.53, 5.36	0.15		3.71	0.72, 6.71	0.009	0.35	1.3	-1.70, 4.31	0.89	

Table 3 Linear Mixed-Effect model analyses for the secondary outcomes

Outcomes	Time Point				Yoga Vs Breathing exercise and relaxation				Yoga Vs Control				Breathing exercise and relaxation Vs Control			Over-all *P*
		Yoga (*n*= 142)	Breathing exercise and relaxation (*n*= 142)	Control (*n*= 140)	Estimate for Difference	95% CI	*P*	Hedge's g	Estimate for Difference	95% CI	*P*	Hedge's g	Estimate for Difference	95% CI	*P*	
		Mean (SD)	Mean (SD)	Mean (SD)												
Arm symptoms	Baseline	20.21 (18.11)	20.71 (18.23)	21.02 (18.04)												0.97
	Immediate post-intervention	20.91 (16.29)	21.84 (16.53)	18.60 (17.29)	-0.93	-5.61, 3.74	1.00	-0.06	-2.31	-7.11, 2.50	0.75	0.14	-3.24	-8.08, 1.60	0.33	
	3-month	18.49 (15.34)	18.03 (15.78)	19.23 (16.45)	0.46	-3.97, 4.89	1.00	0.03	0.75	-3.80, 5.30	1.00	-0.05	1.21	-3.40, 5.82	1.00	
	6-month	17.60 (15.46)	18.31 (15.80)	19.07 (15.99)	-0.71	-5.16, 3.74	1.00	-0.05	1.47	-3.03, 5.97	1.00	-0.09	0.76	-3.78, 5.31	1.00	
	12-month	15.46 (15.31)	15.29 (15.65)	16.49 (15.87)	0.18	-4.24, 4.59	1.00	0.01	1.03	-3.43, 5.49	1.00	-0.07	1.21	-3.30, 5.72	1.00	
Breast symptoms	Baseline	17.90 (15.93)	19.67 (16.04)	18.98 (15.88)												0.70
	Immediate post-intervention	18.15 (13.99)	17.83 (14.20)	15.44 (14.96)	0.32	-3.70, 4.33	1.00	0.02	-2.71	-6.85, 1.44	0.35	0.19	-2.39	-6.56, 1.78	0.51	
	3-month	15.02 (12.77)	14.60 (13.17)	12.97 (13.82)	0.42	-3.28, 4.11	1.00	0.03	-2.05	-5.85, 1.76	0.59	0.15	-1.63	-5.49, 2.23	0.93	
	6-month	12.67 (12.13)	12.30 (12.42)	12.37 (12.58)	0.38	-3.12, 3.88	1.00	0.03	-0.30	-3.83, 3.24	1.00	0.02	0.08	-3.50, 3.66	1.00	
	12-month	11.23 (13.20)	11.27 (13.51)	11.26 (13.74)	-0.04	-3.85, 3.77	1.00	0.00	0.03	-3.82, 3.89	1.00	0.00	-0.01	-3.91, 3.89	1.00	
Emotional functioning	Baseline	78.58 (19.50)	79.59 (19.63)	79.17 (19.43)												0.79
	Immediate post-intervention	80.27 (18.18)	78.58 (18.42)	80.88 (19.10)	1.69	-3.52, 6.91	1.00	0.09	0.61	-4.72, 5.94	1.00	-0.03	2.30	-3.06, 7.67	0.91	
	3-month	80.60 (17.68)	81.25 (18.12)	83.20 (18.75)	-0.65	-5.75, 4.46	1.00	-0.04	2.60	-2.61, 7.81	0.70	-0.14	1.95	-3.32, 7.23	1.00	
	6-month	82.67 (17.25)	84.29 (17.58)	84.92 (17.72)	-1.63	-6.59, 3.34	1.00	-0.09	2.25	-2.75, 7.26	0.84	-0.13	0.63	-4.42, 5.68	1.00	
	12-month	84.09 (18.79)	84.80 (19.17)	84.00 (19.40)	-0.70	-6.12, 4.71	1.00	-0.04	-0.10	-5.56, 5.37	1.00	0.01	-0.80	-6.32, 4.71	1.00	
Role functioning	Baseline	85.01 (19.75)	84.35 (19.89)	86.15 (19.68)												0.30
	Immediate post-intervention	86.22 (16.84)	86.32 (17.11)	89.10 (18.06)	-0.10	-4.94, 4.74	1.00	-0.01	2.88	-2.11, 7.88	0.50	-0.16	2.78	-2.25, 7.81	0.56	

Table 3 (continued)

Outcomes	Time Point				Yoga Vs Breathing exercise and relaxation				Yoga Vs Control				Breathing exercise and relaxation Vs Control			Overall *P*
		Yoga (*n*= 142)	Breathing exercise and relaxation (*n*= 142)	Control (*n*= 140)	Estimate for Difference	95% CI	*P*	Hedge's g	Estimate for Difference	95% CI	*P*	Hedge's g	Estimate for Difference	95% CI	*P*	
		Mean (SD)	Mean (SD)	Mean (SD)												
	3-month	88.47 (16.09)	89.70 (16.61)	92.28 (17.50)	-1.23	-5.89, 3.44	1.00	-0.07	3.81	-1.00, 8.62	0.17	-0.23	2.59	-2.30, 7.47	0.61	
	6-month	89.58 (16.52)	89.51 (16.91)	91.57 (17.18)	0.07	-4.69, 4.84	1.00	0.00	1.99	-2.83, 6.81	0.97	-0.12	2.06	-2.82, 6.94	0.93	
	12-month	92.95 (15.61)	92.44 (15.98)	92.81 (16.26)	0.52	-3.99, 5.02	1.00	0.03	-0.15	-4.71, 4.42	1.00	0.01	0.37	-4.24, 4.99	1.00	
Physical functioning	Baseline	85.59 (13.76)	84.31 (13.86)	86.49 (13.71)												0.42
	Immediate post-intervention	86.21 (12.36)	86.17 (12.54)	88.29 (13.09)	0.05	-3.50, 3.59	1.00	0.00	2.07	-1.57, 5.71	0.52	-0.16	2.12	-1.55, 5.78	0.50	
	3-month	87.69 (10.86)	90.91 (11.14)	90.29 (11.55)	-3.22	-6.36, -0.09	0.04	-0.29	2.60	-0.61, 5.81	0.16	-0.23	-0.62	-3.87, 2.63	1.00	
	6-month	89.70 (11.30)	88.20 (11.54)	90.37 (11.65)	1.50	-1.76, 4.75	0.81	0.13	0.68	-2.61, 3.96	1.00	-0.06	2.17	-1.14, 5.49	0.35	
	12-month	90.36 (12.33)	89.49 (12.60)	90.32 (12.78)	0.87	-2.68, 4.42	1.00	0.07	-0.04	-3.63, 3.55	1.00	0.00	0.83	-2.80, 4.45	1.00	
Social functioning	Baseline	82.33 (21.21)	81.97 (21.35)	84.01 (21.13)												0.09
	Immediate post-intervention	81.20 (19.65)	82.19 (19.95)	88.35 (20.98)	-0.99	-6.63, 4.65	1.00	-0.05	7.14	1.33, 12.96	0.01	-0.35	6.16	0.30, 12.01	0.04	
	3-month	86.67 (17.14)	90.84 (17.66)	93.60 (18.47)	-4.17	-9.13, 0.79	0.13	-0.24	6.93	1.83, 12.03	<0.001	-0.39	2.76	-2.41, 7.93	0.60	
	6-month	90.26 (17.05)	90.31 (17.45)	91.28 (17.68)	-0.05	-4.97, 4.87	1.00	0.00	1.03	-3.94, 6.00	1.00	-0.06	0.98	-4.05, 6.00	1.00	
	12-month	91.35 (17.37)	90.39 (17.78)	91.66 (18.04)	0.95	-4.06, 5.96	1.00	0.05	0.32	-4.75, 5.39	1.00	-0.02	1.27	-3.85, 6.39	1.00	
Cognitive functioning	Baseline	80.09 (18.60)	78.69 (18.72)	80.07 (18.53)												0.92
	Immediate post-intervention	78.34 (18.94)	78.54 (19.17)	78.61 (19.84)	-0.20	-5.63, 5.22	1.00	-0.01	0.27	-5.27, 5.81	1.00	-0.01	0.07	-5.50, 5.65	1.00	
	3-month	80.81 (19.03)	82.50 (19.52)	84.55 (20.22)	-1.69	-7.18, 3.80	1.00	-0.09	3.74	-1.87, 9.35	0.33	-0.19	2.05	-3.63, 7.72	1.00	
	6-month	82.29 (19.20)	82.31 (19.61)	83.23 (19.81)	-0.03	-5.55, 5.50	1.00	0.00	0.94	-4.63, 6.51	1.00	-0.05	0.91	-4.71, 6.54	1.00	

Table 3 (continued)

Outcomes	Time Point				Yoga Vs Breathing exercise and relaxation				Yoga Vs Control				Breathing exercise and relaxation Vs Control			Overall *P*
		Yoga (*n*= 142)	Breathing exercise and relaxation (*n*= 142)	Control (*n*= 140)	Estimate for Difference	95% CI	*P*	Hedge's g	Estimate for Difference	95% CI	*P*	Hedge's g	Estimate for Difference	95% CI	*P*	
		Mean (SD)	Mean (SD)	Mean (SD)												
	12-month	84.99 (19.08)	82.25 (19.48)	81.63 (19.72)	2.75	-2.74, 8.24	0.69	0.14	-3.37	-8.91, 2.18	0.44	0.17	-0.62	-6.22, 4.98	1.00	
Mental fatigue	Baseline	4.62 (3.91)	4.42 (3.93)	4.69 (3.89)												0.84
	Immediate post-intervention	5.00 (3.80)	5.11 (3.85)	4.15 (3.99)	-0.11	-1.20, 0.99	1.00	-0.03	-0.85	-1.97, 0.26	0.20	0.22	-0.96	-2.08, 0.17	0.12	
	3-month	4.71 (3.73)	4.09 (3.81)	4.22 (3.95)	0.61	-0.46, 1.69	0.52	0.16	-0.48	-1.58, 0.62	0.88	0.12	0.13	-0.98, 1.24	1.00	
	6-month	3.95 (3.87)	4.50 (3.94)	3.90 (3.99)	-0.55	-1.67, 0.56	0.70	-0.14	-0.04	-1.17, 1.08	1.00	0.01	-0.60	-1.73, 0.54	0.62	
	12-month	3.82 (3.99)	4.06 (4.08)	4.20 (4.12)	-0.24	-1.39, 0.91	1.00	-0.06	0.38	-0.78, 1.54	1.00	-0.09	0.14	-1.03, 1.31	1.00	
Physical fatigue	Baseline	10.61 (7.82)	10.12 (7.88)	10.14 (7.79)												0.62
	Immediate post-intervention	9.49 (7.19)	9.92 (7.28)	7.77 (7.58)	-0.44	-2.49, 1.63	1.00	-0.06	-1.72	-3.83, 0.40	0.16	0.23	-2.15	-4.28, -0.02	0.05	
	3-month	8.18 (6.72)	6.81 (6.90)	6.99 (7.17)	1.37	-0.57, 3.31	0.27	0.20	-1.19	-3.18, 0.80	0.46	0.17	0.18	-1.83, 2.19	1.00	
	6-month	7.40 (7.15)	7.60 (7.30)	7.41 (7.38)	-0.20	-2.26, 1.86	1.00	-0.03	0.01	-2.07, 2.09	1.00	0.00	-0.19	-2.29, 1.91	1.00	
	12-month	7.53 (7.25)	6.97 (7.40)	7.58 (7.49)	0.56	-1.53, 2.64	1.00	0.08	0.05	-2.05, 2.16	1.00	-0.01	0.61	-1.52, 2.74	1.00	
Anxiety	Baseline	4.11 (3.52)	4.12 (3.54)	4.38 (3.50)												0.99
	Immediate post-intervention	4.47 (3.57)	4.52 (3.61)	4.07 (3.73)	-0.05	-1.07, 0.98	1.00	-0.01	-0.40	-1.45, 0.64	1.00	0.11	-0.45	-1.50, 0.60	0.91	
	3-month	3.54 (3.59)	3.62 (3.67)	3.91 (3.79)	-0.08	-1.11, 0.95	1.00	-0.02	0.37	-0.69, 1.42	1.00	-0.10	0.29	-0.78, 1.36	1.00	
	6-month	3.39 (3.62)	3.64 (3.69)	3.35 (3.73)	-0.25	-1.29, 0.79	1.00	-0.07	-0.05	-1.10, 1.00	1.00	0.01	-0.30	-1.36, 0.76	1.00	
	12-month	3.54 (3.60)	3.21 (3.68)	3.58 (3.72)	0.33	-0.71, 1.37	1.00	0.09	0.04	-1.01, 1.08	1.00	-0.01	0.37	-0.69, 1.43	1.00	
Depression	Baseline	4.04 (3.30)	3.78 (3.31)	4.00 (3.28)												0.60
	Immediate post-intervention	3.93 (3.35)	3.99 (3.40)	3.27 (3.50)	-0.06	-1.02, 0.90	1.00	-0.02	-0.65	-1.63, 0.32	0.33	0.19	-0.72	-1.70, 0.27	0.24	

Table 3 (continued)

Outcomes	Time Point				Yoga Vs Breathing exercise and relaxation				Yoga Vs Control				Breathing exercise and relaxation Vs Control			Overall *P*
		Yoga (*n*= 142)	Breathing exercise and relaxation (*n*= 142)	Control (*n*= 140)	Estimate for Difference	95% CI	*P*	Hedge's g	Estimate for Difference	95% CI	*P*	Hedge's g	Estimate for Difference	95% CI	*P*	
		Mean (SD)	Mean (SD)	Mean (SD)												
	3-month	3.39 (3.37)	3.08 (3.44)	3.08 (3.56)	0.31	-0.67, 1.28	1.00	0.09	-0.31	-1.30, 0.68	1.00	0.09	-0.01	-1.01, 0.99	1.00	
	6-month	3.18 (3.40)	2.91 (3.47)	2.96 (3.49)	0.26	-0.71, 1.24	1.00	0.08	-0.22	-1.21, 0.76	1.00	0.06	0.04	-0.95, 1.04	1.00	
	12-month	3.24 (3.37)	2.75 (3.44)	2.89 (3.49)	0.49	-0.48, 1.46	0.68	0.14	-0.35	-1.33, 0.63	1.00	0.10	0.14	-0.85, 1.13	1.00	
Sleep quality	Baseline	7.84 (3.57)	7.82 (3.60)	7.73 (3.57)												0.59
	Immediate post-intervention	7.38 (3.62)	7.21 (3.67)	7.64 (3.77)	0.17	-0.87, 1.21	1.00	0.05	0.26	-0.79, 1.32	1.00	-0.07	0.43	-0.63, 1.49	0.99	
	3-month	7.27 (3.65)	6.76 (3.73)	7.37 (3.83)	0.51	-0.54, 1.56	0.73	0.14	0.10	-0.97, 1.17	1.00	-0.03	0.61	-0.47, 1.69	0.53	
	6-month	7.28 (3.67)	6.67 (3.75)	6.57 (3.77)	0.60	-0.45, 1.66	0.52	0.16	-0.70	-1.76, 0.36	0.34	0.19	-0.10	-1.17, 0.98	1.00	
	12-month	7.17 (3.66)	6.64 (3.73)	6.99 (3.76)	0.53	-0.52, 1.58	0.68	0.14	-0.18	-1.24, 0.88	1.00	0.05	0.36	-0.72, 1.43	1.00	
Pain intensity	Baseline	36.10 (21.56)	36.38 (21.35)	33.74 (21.52)												0.52
	Immediate post-intervention	32.73 (21.49)	34.28 (21.96)	32.89 (23.48)	-1.56	-7.74, 4.63	1.00	-0.07	0.16	-6.26, 6.59	1.00	-0.01	-1.39	-7.88, 5.10	1.00	
	3-month	28.63 (22.55)	31.57 (23.05)	32.58 (24.99)	-2.94	-9.43, 3.55	0.83	-0.13	3.95	-2.85, 10.74	0.49	-0.17	1.01	-5.86, 7.87	1.00	
	6-month	30.29 (22.71)	33.94 (23.42)	33.09 (25.14)	-3.64	-10.21, 2.92	0.55	-0.16	2.79	-4.05, 9.64	0.98	-0.12	-0.85	-7.79, 6.09	1.00	
	12-month	31.94 (23.14)	34.08 (23.88)	31.16 (25.47)	-2.14	-8.83, 4.55	1.00	-0.09	-0.79	-7.74, 6.16	1.00	0.03	-2.93	-9.98, 4.12	0.96	
Pain disability	Baseline	31.08 (24.76)	32.23 (24.51)	33.12 (24.72)												0.84
	Immediate post-intervention	29.17 (24.67)	26.61 (25.22)	27.25 (26.97)	2.57	-4.53, 9.67	1.00	0.10	-1.92	-9.30, 5.46	1.00	0.07	0.65	-6.81, 8.10	1.00	
	3-month	22.86 (25.89)	23.03 (26.48)	25.20 (28.73)	-0.17	-7.62, 7.28	1.00	-0.01	2.34	-5.47, 10.15	1.00	-0.09	2.17	-5.72, 10.06	1.00	
	6-month	23.38 (26.10)	27.06 (26.91)	27.50 (28.93)	-3.68	-11.22, 3.87	0.73	-0.14	4.12	-3.75, 11.99	0.63	-0.15	0.44	-7.54, 8.42	1.00	

Table 3 (continued)

Outcomes	Time Point	Yoga (*n*= 142)	Breathing exercise and relaxation (*n*= 142)	Control (*n*= 140)	Yoga Vs Breathing exercise and relaxation				Yoga Vs Control				Breathing exercise and relaxation Vs Control			Over-all *P*
		Mean (SD)	Mean (SD)	Mean (SD)	Estimate for Difference	95% CI	*P*	Hedge's g	Estimate for Difference	95% CI	*P*	Hedge's g	Estimate for Difference	95% CI	*P*	
	12-month	22.97 (26.61)	24.31 (27.47)	22.67 (29.33)	-1.34	-9.03, 6.36	1.00	-0.05	-0.31	-8.30, 7.69	1.00	0.01	-1.64	-9.76, 6.47	1.00	

post-intervention compared to patients in Yoga (mean difference 7.14, 95% CI 1.33, 12.96, $p = 0.01$) or Active control groups (mean difference 6.16, 95% CI 0.30, 12.01, $p = 0.004$); at 3-month post-intervention compared to patients in Yoga group (mean difference 6.93, 95% CI 1.83, 12.03, $p < 0.001$).

Sensitivity Analysis

Sensitivity analysis conducted by adjusting for the effects of disease stage, type of surgery, age, adjuvant radiation therapy, and surgical side (Supplementary Table S3) showed intervention effects similar to the primary results, suggesting the robustness of the intervention effect. Furthermore, adjusting for the effects of disease stage, type of surgery, age, adjuvant radiation therapy, and surgical side, linear mixed growth modelling analysis showed consistent results. While there was an overall significant improvement in the shoulder rotation flexibility over time in this sample (b = 7.95, SE = 1.34, $p < 0.001$), the Yoga group showed a significantly faster rate of improvement as compared with the Breathing exercise and Relaxation (b = -6.87, SE = 1.85, $p < 0.001$) and the Passive control (b = -5.37, SE = 1.93, $p < 0.01$) groups. Similarly, while there was an overall significant improvement in the left hand up back scratch test over time in this sample (b = 5.99, SE = 1.44, $p < 0.001$), the Yoga group showed a significantly faster rate of improvement than the Passive control (b= -5.72, SE = 2.13, $p < 0.05$) groups. There was also an overall significant improvement in the right hand up back scratch test over time in this sample (b = 4.30, SE = 1.17, $p < 0.001$), the Yoga group showed a significantly faster rate of improvement than the Passive control (b=-5.40, SE = 1.76, $p < 0.05$) groups.

Discussion

This three-arm RCT showed that the 12-weekly yoga exercise intervention compared with the usual-care control significantly improved shoulder rotation flexibility and in right hand up shoulder range of motion. These effects were stable throughout the 12-month postintervention period. Interestingly, the Breathing exercise & Relaxation control group showed similar improvement in shoulder range of motion compared to the Yoga group. In the breathing exercise and relaxation intervention, the participants were taught relaxation techniques in combination with breathing exercises. Breathing exercise techniques may reduce muscle tension and pain [20], which in turn may enable patients to stretch further, thereby improving the shoulder range of motion.

The range of motion of the left hand-up shoulder did not significantly vary by intervention group. Using the recommended ranges (below average < -3.5 inches, < – 8.89 cm, normal – 3.5 to 1.5 inches, – 8.89 to 3.81 cm, above average >1.5 inches, >3.81 cm) for female

age 65–69 [22], , we noticed that the baseline left hand up back scratch test scores, assessing shoulder range of motion, were all below average across the three groups, suggesting a greater limited internal rotation of the right shoulder and external rotation of the left shoulder observed in our sample (Table 2). We did not find that shoulder range of motion at baseline differed by breast cancer surgery side. Conversely, the baseline right hand back scratch test scores were within the normal range for all three groups.

Notably, a steady improvement in the shoulder range of motion, even for the left hand up back scratch test scores, was observed over time in both the Yoga and the Breathing exercise & Relaxation control groups, but no improvement was observed in the usual care control group. In the study, yoga instructors concentrated on assisting participants in achieving symmetry by adjusting their postures during practice, while being cautious not to overstretch them to prevent injuries. Furthermore, participants were advised to exercise caution when stretching areas with limited mobility. This approach may lead to a slow and steady improvement in shoulder range of motion, as observed in this study. For individuals with significantly restricted shoulder range of motion (i.e., below average), the intervention effect may take longer to manifest. The current study conducted follow-up assessments only up to 12 months post-intervention. Future studies may require a longer follow-up period to confirm the effect of the intervention.

To our knowledge, this is the first RCT with three arms to evaluate the impact of yoga, breathing exercises combined with relaxation, and standard care on shoulder range of motion in women recovering from breast cancer surgery. The effect sizes of yoga intervention on shoulder range of motion and shoulder rotation flexibility were small to medium. Our findings are consistent with the results of a small-scale trial in which women with breast cancer engaged in a 3-month yoga intervention demonstrated greater improvement in shoulder range of motion compared to those in the waitlist control group [18]. Furthermore, the findings of our study suggest that breathing exercises and relaxation techniques may be as effective as yoga in improving shoulder ROM, highlighting that breathing exercises and relaxation techniques may be a safe and non-invasive supportive intervention that can be readily taught and practiced by patients in their home environment.

While the level of cancer-specific quality of life, breast symptoms, sleep quality, pain, fatigue, anxiety, and depression significantly improved over time, no statistically significant difference was observed between the groups. This is likely a ceiling or floor effect (i.e., large proportions of participants score close to or at either the maximum or minimum possible scores), as the mean baseline scores of health-related quality of life were at the high end and scores of physical symptoms and symptoms of anxiety and depression were at the low end. This suggests that our sample, on average, started off with high functioning and minimum symptom distress at baseline, and therefore may have limited room for improvement, making it difficult to detect noticeable changes.

Interestingly, patients in the Passive control group reported significantly higher social functioning scores immediately post-intervention compared to patients in the Yoga or Active control groups, and at 3-month post-intervention compared to patients in the Yoga group. One possible explanation is that passive-control participants reintegrated into their preexisting social networks more quickly, whereas those in the yoga and active control arms may have shifted their social efforts toward newly formed intervention cohorts. Until strong bonds solidify within these new groups, this reallocating of social time could temporarily reduce contact with established friends, producing a transient decline in perceived social support.

The current findings contrast with several meta-analyses in which yoga intervention appeared to be beneficial in improving health-related quality of life and psychosocial outcomes in women with breast cancer [10, 13, 14, 33]. Previous meta-analyses have included patients receiving active breast cancer treatment and those who had completed treatment. Patients receiving active treatment are likely to experience more symptom distress and poor functioning, potentially benefitting more from yoga intervention.

The strengths of this study include the inclusion of an active control arm in addition to usual care, a high completion rate of the intervention (69% in yoga and 62% in breathing exercise and relaxation groups for completing over 50% of the sessions), a relatively long follow-up, and a low attrition rate. Our study showed that almost one in two participants maintained yoga self-practice at least once a week throughout the 1-year post-intervention. In contrast, the majority of participants receiving the standard video distributed as postoperative exercise for shoulder mobility seldom performed this exercise. Our findings demonstrate the feasibility and effectiveness of yoga intervention in improving upper arm morbidity after breast cancer surgery. To increase the external validity of the study findings, our recruitment was solely conducted at oncology outpatient clinics, where potential participants were awaiting their medical consultations. To minimize self-selection bias, we did not use social media or newsletters for recruitment.

Nevertheless, caution must be exercised when interpreting the study findings due to the moderate refusal rate (31%) for trial participation. Furthermore, having yoga instructors deliver both yoga and breath exercise

and relaxation interventions may introduce therapist-bias in the current trial. To minimize this potential bias, all yoga instructors attended our training workshop and were asked to follow the standardized structure prescribed for both interventions.

Conclusions

In conclusion, our study showed that yoga intervention may reduce arm morbidity resulting from breast cancer treatment, as we showed significantly greater improvement in shoulder range of motion for women receiving the yoga intervention in comparison to women receiving breath exercise and relaxation or passive control interventions. With capacity building, community-based yoga exercise may be considered as an alternative intervention for improving upper extremity function in women undergoing breast cancer treatment. The current study mainly focused on shoulder range of motion and did not assess other upper arm morbidities such as grip strength and lymphedema. Future studies should examine the effect of yoga intervention on other upper-extremity impairments resulting from breast cancer treatment.

Abbreviations

ROM	Range of motion
RCT	Randomized controlled trial
CONSORT	Consolidated Standards of Reporting Trials
QoL	Quality of Life
QLQ-30	EORTC General Quality of Life Questionnaire
PSQI	The Pittsburgh Sleep Quality Index
HADS	The Hospital Anxiety and Depression Scale
LLM	Linear mixed-effects models

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

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Author Contributions

WWTL had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. WWTL was responsible for the concept and design of the study, as well as drafting the manuscript and supervising the project. Both WWTL and DWLN handled the acquisition, analysis, and interpretation of data, and conducting the statistical analysis. All authors contributed to the revision of the manuscript and provided administrative, technical, or material support.

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Data Availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request (email: wwtlam@hku.hk).

Declarations

Ethics Approval and Consent to Participate

This study was approved by the Institutional Review Board of the University of Hong Kong and Hospital Ethics Committee from multicenter studies (Reference no. UW 12–241) and was registered at the HKU Clinical Trials Registry (HKUCTR-1600). Consecutive patients meeting eligibility criteria were screened by research assistants and invited to participate. All participants provided written informed consent after receiving a full explanation of the study's purpose, procedures, their rights, and the measures in place to protect anonymity and confidentiality.

Consent for Publication

Not applicable.

Competing Interests

The authors declare that they have no competing interests.

Author details

[1]LKS Faculty of Medicine, School of Public Health, Centre for Psycho-Oncology Research and Training, The University of Hong Kong, Hong Kong, Hong Kong SAR, China
[2]LKS Faculty of Medicine, Jockey Club Institute of Cancer Care, The University of Hong Kong, Hong Kong, Hong Kong SAR, China
[3]LKS Faculty of Medicine, School of Nursing, The University of Hong Kong, Hong Kong, Hong Kong SAR, China
[4]LKS Faculty of Medicine, School of Clinical Medicine, Department of Surgery, The University of Hong Kong, Hong Kong, Hong Kong SAR, China
[5]Department of Clinical Oncology, Pamela Youde Nethersole Eastern Hospital, Hospital Authority, Hong Kong, Hong Kong SAR, China
[6]LKS Faculty of Medicine, School of Clinical Medicine, Department of Clinical Oncology, The University of Hong Kong, Hong Kong, Hong Kong SAR, China
[7]Department of Surgery, Kwong Wah Hospital, Hospital Authority, Hong Kong, Hong Kong SAR, China

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