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CLINICAL TRIAL

Pectoral stretching program for women undergoing radiotherapy for breast cancer

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Abstract Surgery and radiotherapy commonly cause adverse musculoskeletal problems, particularly loss of strength and range of motion, in the upper quadrant of breast cancer patients. Few well-designed studies have investigated whether these impairments can be prevented. Stretching is an effective technique for increasing range of motion, hence the aim of this study was to investigate whether a stretching program reduced acute musculoskeletal impairments in patients undergoing radiotherapy for breast cancer. Sixty-four women were recruited prior to commencement of radiotherapy following breast cancer surgery. Participants were randomised to either a control or stretch group. Participants in both groups were reviewed by the physical therapist on a weekly basis for approximately 6 weeks, and were given general information about skin care and lymphedema. The control group received no advice about exercise. The stretch group received instruction on low-load, prolonged pectoral stretches, which were to be performed daily and were checked at weekly visits. Shoulder range of motion, strength, arm circumference, and quality of life measurements were taken prior to, and at completion of radiotherapy, and at 7 months after radiotherapy. There was no difference in any outcome between groups. Breast symptoms increased for both groups during radiotherapy, without loss of strength or range of movement. The incidence of lymphedema during the study was low for both groups and did not differ between groups. The pectoral stretching program did not influence the outcomes measured because the symptoms reported by patients were not a consequence of contracture.

Keywords Breast cancer · Radiotherapy · Exercise · Physical therapy · Shoulder

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Introduction

Upper quadrant problems are significant for women following breast cancer treatment and have been reported in one third of survivors [1–4]. Factors which contribute to upper limb impairments include radiotherapy and surgery to the axilla [2, 4–6]. At our institution, 51% of breast cancer patients during the peroid of our study received breast conserving surgery and 49% received mastectomy, with 64% of breast cancer patients further treated by radiotherapy [7]. Radiotherapy treatment fields usually involve the breast or chest wall and occasionally the supraclavicular fossa [8] and is a common intervention for women treated for breast cancer. Treatment of the axilla using radiotherapy has declined significantly in the past decade due to its known adverse upper quadrant effects [9–14].

Arm and chest wall problems affect the upper quadrant of women who receive radiotherapy to the breast or chest wall [4, 15–17]. Long-term problems associated with radiotherapy to the breast and chest wall include reduction in shoulder range. For example, one third of patients who received surgery and radiotherapy [1, 2] had limitation in any shoulder range at 18 months or more following treatment. No study has investigated whether an intervention during the radiotherapy period may help prevent upper quadrant problems in breast cancer patients.

These long-term upper quadrant problems are linked to radiotherapy via various pathogenetic pathways. In the acute treatment phase, there may be increased sensitivity and desquamation in the treated area, as well as inflammation of the pectorals and other chest wall muscles, resulting in pain and pain-protective behaviours. That is, patients are more likely to protect their chest and use their arm less to avoid pain from these acute side-effects, leading to potential disuse problems including contractures and arm weakness. Clinically, the reluctance to return to normal activity with their affected arm has been observed by researchers in breast cancer patients months and years following breast cancer treatment [18, 19]. Long term effects of radiation, in particular, subcutaneous fibrosis of the pectoral muscle may be another factor causing chronic shoulder restriction and pain [20, 21]. These upper quadrant problems significantly impact on breast cancer survivor's quality of life [22, 23].

Several studies have called for preventative exercise to reduce the incidence of upper quadrant morbidity [24–26]. In particular, Johansson et al. [12] suggested that physical therapy be introduced during the period of radiotherapy. As the pectoral muscle group is at risk of contracture following surgery and radiotherapy to the breast or chest wall, stretching this area would seem important for maintaining muscle length and shoulder mobility. Low-load prolonged stretch is considered necessary, and more effective than high-load brief stretch in retaining sarcomere numbers in muscles at risk of contracture [27]. Thus, the aim of this study was to investigate whether a low-load pectoral stretching program effectively reduced acute upper quadrant impairments in patients undergoing radiotherapy for breast cancer. A preliminary report of this study was presented at the 12th Hong Kong International Cancer Congress, 2005 [28].

Methods

A single-blind randomised controlled trial was conducted to assess the effectiveness of a program to stretch the pectoral muscles in women undergoing radiotherapy for breast cancer. Patients who were scheduled for radiotherapy following surgical management for their breast cancer were recruited at their simulation appointment 1 week prior to the commencement of radiotherapy. Their baseline measurements were taken at this time. Participants were randomised to either a control or stretch group using computer-generated randomisation schedule in blocks of 10. Allocation was concealed by the use of numbered opaque envelopes. The intervention period was of equal duration to the radiotherapy period, i.e. approximately 6 weeks. Participants were remeasured at the conclusion of radiotherapy and also 7 months after the completion of radiotherapy. This study was approved by Sydney South West Area Health and University of Sydney Human Ethics Committee. Written informed consent was obtained from all participants.

Participants

Patients were included if they had undergone breast cancer surgery and were receiving radiotherapy to the breast or chest wall in either two fields (medial and lateral tangents: 50Gy in 25#, or 42.5Gy in 16#), or three fields including a supraclavicular field (50Gy in 25#). Patients were excluded if they received radiotherapy to the axilla. Allowing for 10% drop-outs, a sample size of 60 achieved 80% power to detect a difference of 10° in the primary outcome of horizontal extension. A 10° loss at the shoulder was used because it was found to be the baseline for patient reports of shoulder or arm stiffness following breast cancer treatment [12]. Sixty-four consecutive patients who met the inclusion criteria were recruited. A total of 61 participants were randomly assigned to either the control (n = 30) or the stretch group (n = 31) (Fig. 1).

The mean (±SD) age was 53 ± 11 years for the control group and 55 ± 13 years for the stretch group (Table 1). The mean body mass index (BMI) was 27.3 ± 5.5 for the control group and 25.9 ± 4.0 for the stretch group. The dominant side was affected in approximately half of the participants in each group. A similar number of participants who had undergone chemotherapy were included in each group. More participants in the control group (n = 27) had axillary surgery than in the stretch group (n = 19). Two participants in the control group had lymphedema at baseline compared to four in the stretch group. Pain was felt at end range in one or more directions of shoulder movement in 16 participants of each group at baseline (Table 1).

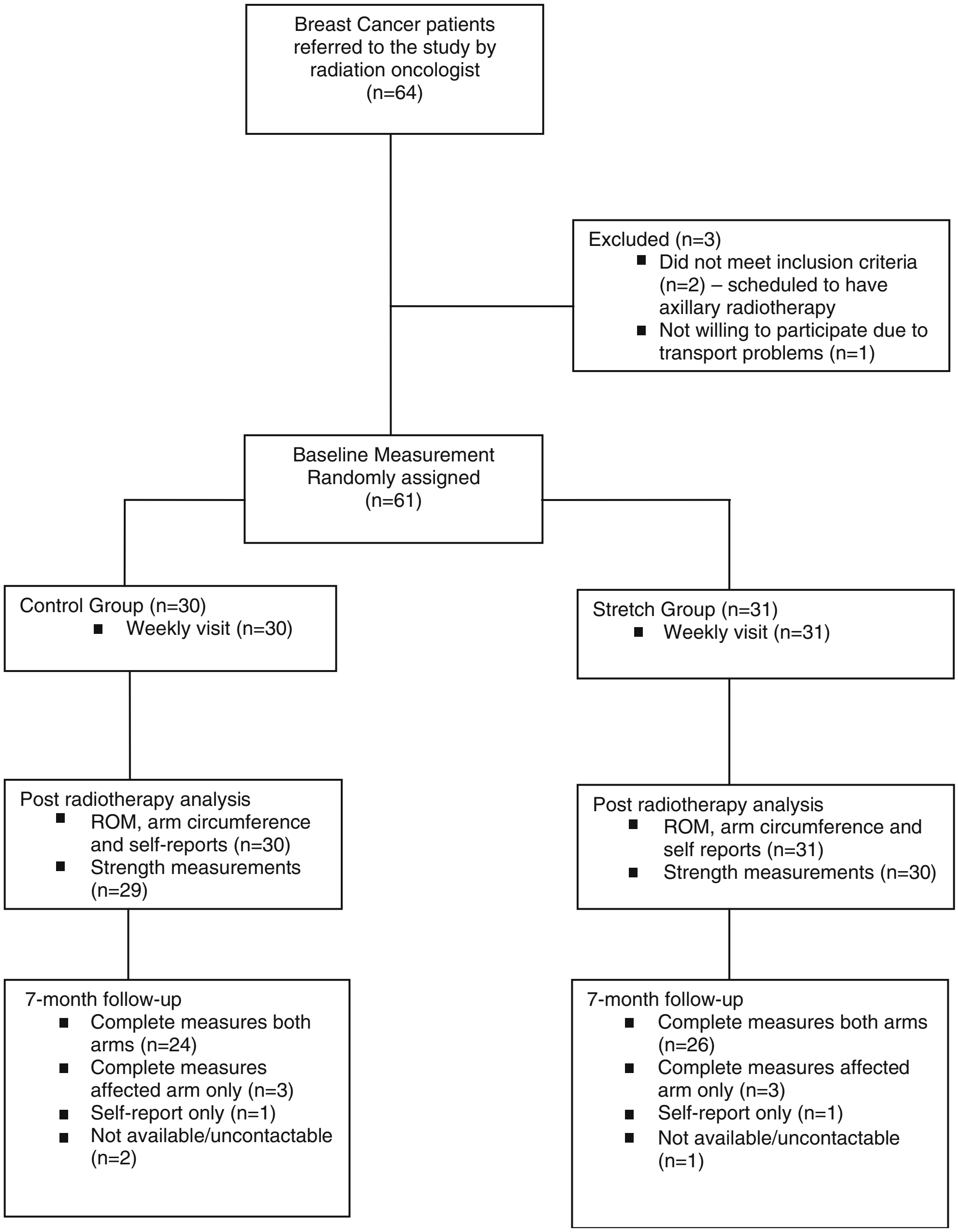

Fig. 1 Flow chart of study design and participant retention

Interventions

Usual care for patients after breast cancer surgery was to follow independently an exercise program outlined in a pamphlet given to them after breast cancer surgery. The exercise program consisted of gentle shoulder range of motion exercises. In addition to usual care, participants in both groups were seen by the physical therapist on a weekly basis at the hospital during their radiotherapy. All patients were given a booklet to record use of medication, any treatments by health professionals, and exercises performed during the course of radiotherapy.

Participants in the control group did not receive any exercise advice during their weekly sessions. They were seen by the physical therapist for skin care and lymphedema information. Skin quality was reviewed, and some participants were referred to nursing staff for monitoring of skin reactions.

In addition to skin care and lymphedema advice, participants in the stretch group were given a pectoral muscle stretching program. This was individualised and

Table 1 Participants' characteristics

	Control (n = 30)	Stretch (n = 31)
Age[a]	53 (12)	55 (13)
BMI[a]	27.3 (5.5)	25.9 (4.0)
Affected side (dominant: non-dominant)[b]	16:14	15:16
Time since surgery (months)[a]	3.4 (1.8)	3.7 (1.9)
Cancer stage grouping[b]		
DCIS	4	6
Stage I	11	10
Stage II	10	13
Stage III	5	2
XRT Machine (4MV: 6MV)	5:25	4:27
No. of XRT fields (2:3)[b]	17:13	21:10
XRT Dosage (42.5Gy in 16#: 50Gy in 25#)[b]	5:25	8:23
Boost Radiation (10Gy in 4#: 10Gy in 5#)[b]	4:14	5:12
Surgery type (mastectomy: conservative) [b]	7:23	6:25
Axillary surgery[b]		
None	4	12
Sentinel node biopsy	13	8
Axillary dissection	13	11
Chemotherapy[b]	18	16
Tamoxifen or Arimidex[b]	23	17
Lymphedema at baseline[b]	2	4
Pain on maximal range at baseline[b]	16	16

[a] Mean ± SD,

[b] Number of patients

consisted of low-load, prolonged, passive stretches of pectoralis major and minor while in supine-lying. For pectoralis major, the arm was positioned at 90° abduction and the arm was held externally rotated with a 2 kg weight. For pectoralis minor, the arm was positioned at 135° abduction and held external rotated with a 2 kg weight. Each stretch position was held for up to 10 min, twice per day. The positions were often adjusted so that participants could feel a stretch at the front of their shoulder or chest. Some participants required the use of a towel under the elbow or forearm for support.

Exercises were checked at each weekly session to review technique. Participants were also provided with a compliance diary and were asked to record any symptoms they experienced during or after the exercises. All participants in the stretching group were encouraged to continue stretching until their follow-up at 7 months.

Measurements

Participants were measured by a physical therapist blinded to group allocation at each of the three measurement occasions. At the baseline assessment, age, weight, height and cancer treatment regimens were recorded, as well as shoulder range, strength, pain, arm circumference measures and quality of life. The protocol was revised after six patients (control n = 3, stretch n = 3) were measured at the 7-month follow-up to include shoulder range and strength measurements of the unaffected arm. Therefore, a total of 50 participants (control n = 24, stretch n = 26) had complete data for both arms at the 7-months follow-up.

Outcome measures

The primary outcome measure was passive range of movement for horizontal extension. Secondary outcome measures included passive range of movement for forward flexion and external rotation, active range of movement for abduction, strength of shoulder muscles, arm swelling and quality of life.

Passive forward flexion, horizontal extension and external rotation at the shoulder were assessed using an inclinometer with the patient in supine to maximise scapula stability. Gravity was used as a standardised force for these measurements. Active shoulder abduction was assessed using an inclinometer with the patient in sitting. To accommodate for ‘‘creep’’, range of motion was measured three times in each direction, and the greatest range was used for analysis. Pain was measured using a standardised 11-point scale after the first attempt of each movement.

Forward flexion, horizontal flexion, horizontal extension, abduction, and external rotation strength were measured in 90° elevation. Force was quantified using a digital dynamometer. For each movement direction, three maximum voluntary contractions were performed, and the strongest contraction of the three attempts was recorded. Pain was measured using a standardised 11-point scale after the first attempt of strength measurement.

Arm swelling was assessed using circumferential measurements taken at 10 cm intervals from the ulnar styloid to the axilla of both limbs. This method has been shown to be valid and reliable for measurement of arm swelling [29]. A difference of greater than 2 cm was used in this study to identify or indicate presence of lymphedema.

To assess quality of life, the European Organization for Research and Treatment of Cancer (EORTC) Quality of Life Questionnaire Version 3 (QLQ-C30), and its Breast Module BR23 were used. These are reliable and validated measures of quality of life specific to cancer patients [30].

Statistical analysis

Statistical analysis was carried out using ''intention-to-treat'' analysis. To determine whether there was an increase in range of motion at 7 months following the completion of radiotherapy, two-way repeated measures analysis of variance (ANOVA) was used. The within group factor was arm (affected, unaffected) and the between group factor was group allocation (control, stretch). In addition, two-way repeated measures ANOVAs were used on each outcome of range, strength, and factors related to quality of life to identify any changes over time. The dependant variables were group allocation and time (baseline, post-radiotherapy, and 7 months after radiotherapy). Planned contrasts were performed if significant differences were obtained.

Stepwise linear regression was used to determine whether patient characteristics and treatment factors explained the range obtained at 7 months. Variables included age, BMI, cancer staging (DCIS, Stage I, II, III), type of breast surgery (mastectomy or conservative surgery), axillary surgery, affected side (dominant or non-dominant), time between surgery and radiotherapy, boost treatment, radiotherapy dose (42.5Gy or 50Gy), machine (4 or 6MV), pain at baseline, lymphedema at baseline, and skin desquamation (requiring treatment or not requiring treatment).

One participant's data from the stretch group were not included in the between-limb analysis because she had a frozen shoulder on the unaffected side. Mean scores replaced missing data for outcome measures except questionnaire data. Cases with missing data from questionnaires were excluded from the repeated measures tests, hence there were 29 complete data sets from the control group and 28 from the stretch group. Means and standard deviations are reported in the results unless otherwise stated. Statistical significance was set at $P < 0.05$. Statistical analyses were performed using SPSS Version 12.0 software (SPSS Inc. Chicago, USA).

Results

The majority of patients in the stretch group (28/31) complied with their exercise program. One participant in the stretch group only performed stretches once per day, and another participant discontinued the stretches after one and a half weeks due to lack of time. A third participant discontinued the stretches after 1 week as she felt the stretches were aggravating her concurrent neck and jaw pain on her affected side. No participant continued the stretching routine on a consistent basis after completion of radiotherapy. Participants reported resuming their stretches only if they felt their arm ''tightening''.

Participants in the control group were generally active as a group and exercised during their radiotherapy period. Of the 30 participants in the control group, 14 participants reported regularly exercising and this may have influenced their arm function. These exercises included a combination of arm range of motion exercises ($n = 7$), arm stretching ($n = 3$), tennis ($n = 2$), swimming ($n = 4$), jogging ($n = 2$), walking ($n = 6$), power walking ($n = 2$), cycling ($n = 2$), yoga ($n = 1$), gym ($n = 1$), aerobics ($n = 1$) and tai-chi ($n = 1$). Thirteen participants in the stretch group also reported additional exercises. These included lymphedema exercises ($n = 2$), walking ($n = 4$), yoga ($n = 1$), swimming ($n = 1$), gym ($n = 2$), cycling ($n = 2$) and back exercise ($n = 1$). The data were subsequently grouped post-hoc by participation in regular exercise but no differences in range of motion were detected between regular exercisers and non-exercisers.

There were four new cases of arm swelling in the control group at the 7-month follow-up, compared to one new case in the stretch group. No other adverse events were noted.

No significant differences were found between groups at 7 months for the primary outcome of passive horizontal extension ($P = 0.860$). Similarly, no differences were found for forward flexion ($P = 0.467$), external rotation ($P = 0.590$), or abduction ($P = 0.793$) range of motion (Fig. 2). Small differences (≤6°) were found between arms for horizontal extension ($P = 0.000$) and forward flexion ($P = 0.000$). Horizontal extension range at the affected shoulder for the stretch group was 28.4 ± 9.2° and control groups was 27.9 ± 9.3°, and for the unaffected shoulder was 33.1 ± 9.1° and 31.7 ± 7.7°.

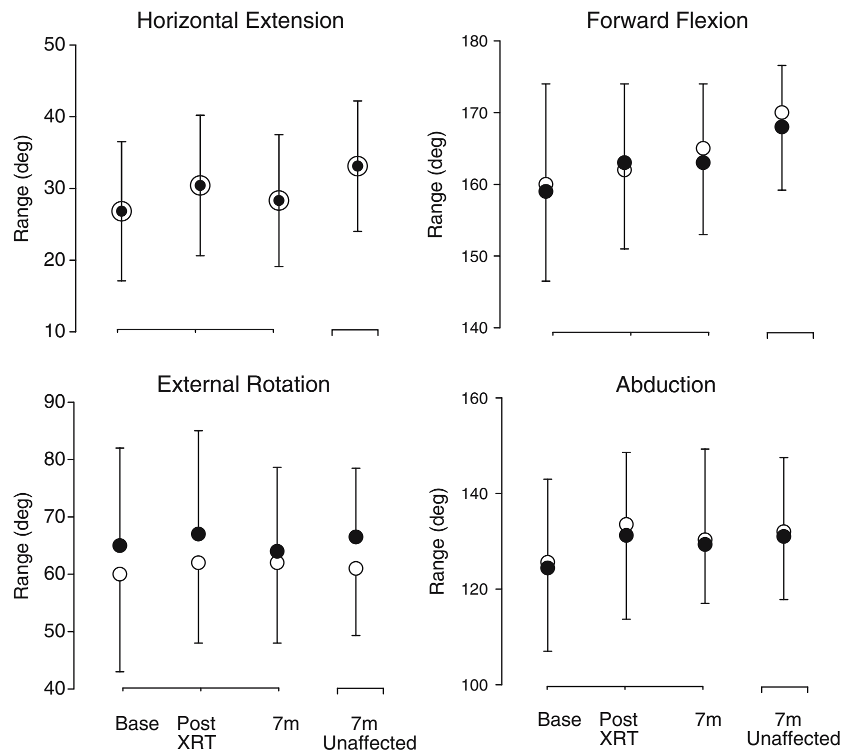

Fig. 2 Range of motion for both groups at the three measurement occasions. Controls are represented by open circles (○) and the stretch group by the closed circles (•)

Forward flexion range at the affected shoulder for the stretch group was 165 ± 8.8° and control groups was 163 ± 10.3°, and for the unaffected shoulder was 170 ± 6.6° and 168 ± 8.8°. No differences were found between arms for external rotation ($P = 0.622$) or active abduction ($P = 0.131$). Thus, both groups attained close to full range of motion at their affected shoulder 7 months post-radiotherapy.

There were no differences in strength between groups at the three time-points measured (Fig. 3). Similarly, no differences were found between groups for the items reported on the EORTC questionnaires.

Outcomes for the cohort

As there were no large differences between groups for the outcome measures, further analysis was conducted on the cohort as a whole. There were small improvements in range from baseline to the completion of radiotherapy. Abduction increased from 125 ± 17.3° at baseline to 132 ± 16.3° at the completion of radiotherapy ($P = 0.000$). Minor mean increases (<4°) were also noted for horizontal extension and forward flexion range during this period. External rotation range did not change significantly throughout the study period ($P \geq 0.3$). All movement directions except external rotation, were restricted at baseline compared with the unaffected arm. Range of motion in the affected arm improved to match that of the normal unaffected side at the completion of radiotherapy, and maintained that range from the completion of radiotherapy to the 7-month follow-up period.

Participants maintained normal arm strength throughout the study. Strength measurements did not differ between arms at any measurement occasion ($P = 0.088$–0.805). Consistent with the side-effects of radiotherapy, breast symptoms increased by two points on a four point scale ranging from ‘‘not at all’’ to ‘‘very much’’ for the cohort at the completion of radiotherapy ($P = 0.000$). Arm symptoms also increased but the mean increase was less than one scale point at the completion of radiotherapy and remained the same at the 7-month follow-up.

Range of movement did not correlate well with any participant or treatment variable. At best, there was a significant but poor correlation between greater horizontal extension range at the conclusion of radiotherapy and boost treatment ($R = 0.4$, $P = 0.001$). Weak positive correlations [31] ($R \leq 0.3$) were also found between greater shoulder range and younger age, lower radiotherapy dose, and conservative surgery.

Discussion

No difference was detected between the stretch and control groups in this study (see Fig. 2 and 3). This

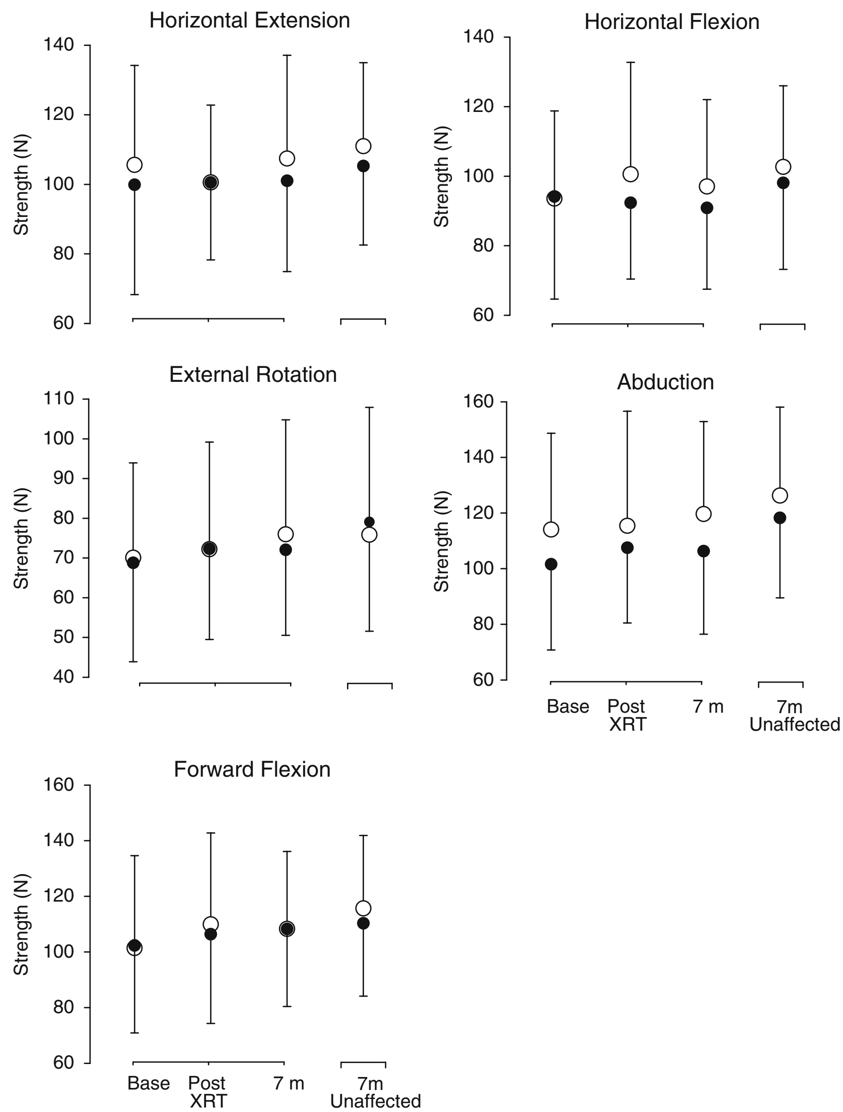

Fig. 3 Strength for both groups at the three measurement occasions. Controls are represented by open circles (○) and the stretch group by the closed circles (•)

study was not underpowered and we are 80% confident that our results are conclusive. Shoulder range of motion for both groups were maintained during radiotherapy, such that there was no decrease in range by the completion of radiotherapy, and even some slight improvement in range for forward flexion, horizontal extension and abduction. The increase in breast and arm symptoms reported in the questionnaires at the conclusion of radiotherapy did not impair range or strength in either group. One explanation for the lack of relationship between breast and arm symptoms reported in the questionnaires and range or strength measured is that these variables may not accurately reflect the symptoms reported by breast cancer patients. Radiotherapy which excludes the axilla may not impair range but may cause more localised upper quadrant symptoms. Vague arm complaints including feelings of stiffness, discomfort, cramping, and tiring pain have been reported in other breast cancer studies [12, 32]. These complaints would be more thoroughly assessed using a validated questionnaire such as the McGill pain questionnaire [33].

In this study, a large proportion of the control group exercised during radiotherapy, performing the exercise routines as shown on the post-operative pamphlets as well as general exercises including swimming, yoga, and tai-chi. The physical therapist in this study may have elicited an effect of encouraging exercise without actually giving specific advice. Seeing a physical therapist on a weekly basis and completing the study's resource use booklets may have acted as reminders to participants in the control group that activity and exercise were important even if no information on prolonged stretching was given to the control group. Although no differences were found when the control data were analysed as subgroups according to participation in regular exercise, it must be noted that the subgroup sample size was small and therefore potentially lacked the power necessary to detect a worthwhile difference.

The findings from this study add to the debate concerning whether stretching prevents muscle or tendon shortening in humans. From the few high quality randomised controlled trials that investigated the effects of stretching, the evidence is mixed. In one study on calf length [34] and one on hamstrings length [35] of spinal cord injured patients, the authors found 30 min daily stretch made no difference to joint range compared to the control legs at the end of the 4 week trial. In contrast, external rotation range increased by 12° in the affected shoulder of stroke patients when they were positioned at end of range for 30 min, 5 days a week over a 4 week period [36]. The effects of stretching require further study but for breast cancer patients undergoing radiotherapy excluding the axilla, the risk of developing contractures during this acute 7 month period may be sufficiently small that prevention programs may not be worthwhile. There is some suggestion that shoulder impairments following radiotherapy may be latent, with reports of impairment starting at 3.9 years after radiotherapy [2]. However, when patients do not have any measurable impairments in range following radiotherapy, it is difficult to convince them to perform preventative stretches, even for 7 months as demonstrated by this study. Further investigations may need to assess the actual incidence of latent subcutaneous fibrosis caused by radiotherapy to assess the need for preventative exercise.

The aim of our study was to assess the effectiveness of pectoral stretching in breast cancer patients with a typical or common presentation. As radiotherapy to the axilla is now rarely performed except in the minority of patients with extensive nodal involvement, we chose to exclude these patients to reflect a more common profile of treatment care for breast cancer patients. Our study sample also consisted of many patients who did not have axillary dissections, reflecting the change in the management of the axilla since the introduction of sentinel node biopsy. Previous studies assessing upper limb impairments exclusively recruited patients with axillary dissections [4, 15–17], which may explain why our participants had better range, although no correlations were found between range and type of axillary surgery at 7-month follow-up.

Our findings demonstrated that pectoral stretching for women undergoing radiotherapy is not necessary as both control and stretch groups maintained their range and strength throughout radiotherapy. Radiotherapy to the breast did not cause contracture or loss of shoulder range as reported in other studies. Objective measurements of range did not correlate with local symptoms reported by women during radiotherapy.

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