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Original Article

Pilot study of effective methods for measuring and stretching for pectoral muscle tightness in breast cancer patients

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Abstract. [Purpose] To evaluate differences in pectoral muscle tightness according to arm abduction angle and to determine the best arm abduction angle for stretching of pectoral muscle tightness in breast cancer patients. [Subjects and Methods] Horizontal abduction differences of shoulders were measured bilaterally by arm abduction to 45°, 90°, and 135° to determine the best arm abduction angle for measuring pectoral muscle tightness. Thirty-two patients were divided into three pectoral muscle stretching groups (A: 45°, B: 90°, and C: 135°). We measured the shoulder range of motion, scores of the Disabilities of the Arm, Shoulder, and Hand, European Organization for Research and Treatment of Cancer Quality of Life Questionnaire and the Breast Module, and pain levels (using a visual analog scale) before and after therapy. [Results] The differences in degree of horizontal abduction between shoulders were significantly larger for arm abduction to 90° and 135° than that to 45°. Groups B and C showed greater improvements in horizontal abduction limitations than group A. [Conclusion] Horizontal abduction differences between shoulders are prominent when arms are abducted to 90° and 135°. The appropriate arm abduction angle for measuring horizontal abduction and effective stretching of pectoral muscle tightness may be >90°.

Key words: Breast neoplasms, Muscle stretching exercise, Rehabilitation

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INTRODUCTION

Breast cancer has become the most frequently diagnosed malignant tumor among women worldwide, and the number of women with breast cancer is increasing[1)]. The increase in breast cancer incidence and improvements in breast cancer survival observed globally[2)] have created the need to improve physical treatment outcomes and quality of life. Although more selective and less-invasive surgical approaches are now used, complications after treatment remain, and these may interfere with daily activities and quality of life. Therefore, rehabilitation programs related to breast cancer treatment have recently gained more attention.

After breast cancer surgery, patients suffer from upper-extremity dysfunction, including pectoral muscle tightness (PMT)[3–6)]. In other studies, PMT was defined as the presence of a limitation of forward flexion of>10°, with no limitation of external rotation, and limited horizontal abduction of >10°[5, 7)]. The prevalence of PMT in one study was 6.3%, 2.3%, and 8.7% at 3, 6, and 12 months after surgery, respectively, and it was higher in patients who underwent mastectomy or radiotherapy[5)]. Postoperative muscle thickening, contraction, and radiation-induced fibrosis may be related to PMT. Patients'

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efforts to protect their surgical sites through thoracic flexion and scapular protraction may aggravate pectoral muscle shortening[8–10].

Sustained PMT after breast cancer treatment may pull the scapula into a protracted and depressed position. It may also lead to other upper-extremity dysfunction, such as myofascial pain syndrome and rotator-cuff disease. These impairments can impact activities of daily living and health-related quality of life[11–13]. Several studies have called for prophylactic exercises to decrease the incidence of upper-quadrant morbidity[14–16]. Stretching is advocated following breast cancer surgery. However, the stretching protocols do not appear to be particularly effective. Little detail about the actual exercises performed in randomized controlled trials has been published[17]. Most patients with PMT seem to stretch in ineffective ways, such as via insufficient arm abduction.

The primary aim of this study was to evaluate differences in horizontal abduction according to arm abduction angle to identify an effective method for diagnosing PMT. The second aim was to determine effective stretching methods for PMT, focusing on arm abduction angle. We conducted a randomized controlled trial to determine the most effective angle for PMT stretching in breast cancer patients.

SUBJECTS AND METHODS

Patients were included in the study if they fulfilled the following criteria: had undergone breast cancer surgery; had been diagnosed with PMT; could attend our institute for treatment and follow-up; and could understand Korean and consent to participate. Patients scheduled for adjuvant treatments, including radiotherapy and chemotherapy, or breast reconstruction, were excluded. Patients were excluded if they had undergone bilateral operations, presented with infection at baseline, or had metastatic disease. In addition, patients were excluded if they had sustained a fracture, undergone surgery of the upper extremities, or suffered any neurological deficit or other injury to either upper extremity. Lastly, patients were excluded if they had axillary web syndrome. Axillary web syndrome was diagnosed on the basis of the presence of taut, palpable cords originating in the axilla and extending distally along the anterior surface of the arm, often below the elbow[18–20]. This study was exempted from institutional review board (IRB) review requirements according to the guidelines of the Asan Medical Center (IRB no. S-2014-0599-0001). All subjects provided written informed consent before enrollment.

Shoulder range of motion, including horizontal abduction, was measured with a goniometer in all patients by a physiotherapist. Before grouping patients, the shoulder horizontal abduction was measured with the arm abducted to 45°, 90°, and 135°. Differences in horizontal abduction angles between shoulders were compared according to arm abduction angles. Patients were then randomly divided into three groups. Prior to randomization, the sample was stratified by whether the patients underwent axillary lymph-node resection or sentinel-node biopsy and whether they underwent a breast-conserving surgery or modified radical mastectomy. Group A patients stretched the pectoral muscle by abducting their arms to 45°, group B patients abducted their arms to 90°, and group C patients abducted their arms to 135°. The stretching exercise program consisted of gentle shoulder range of motion exercises, including pectoral muscle stretching. Patients stretched their pectoral muscle using a T-bar in a supine position, with trunk rotation toward the affected side. While standing, they stretched the pectoral muscle in the corner of the room. Each stretch position was held for up to 15 s, and performed 5–10 times per session, during three sessions per day. The stretching exercise program lasted 4 weeks. Patients attended twice a week, and each week the exercises were modified as required. At the conclusion of the program, patients were encouraged to continue the exercises at home.

At baseline, age, gender, body mass index (BMI), affected side, type of surgery, time since surgery, and method of lymph-node dissection were recorded. The primary outcome measurement was shoulder range of motion, particularly horizontal abduction difference. The secondary outcome measurements were pain, symptoms related to the upper extremity, the ability to perform common activities of daily living, and quality of life. All measurements were recorded before and at the end of the treatment.

Pain related to the upper extremity was measured using a visual analog scale (VAS). VAS is an instrument that measures a characteristic or attitude that is believed to range across a continuum of values. For pain intensity, the scale is most commonly anchored by “no pain” (score of 0) and “pain as bad as it could be” or “worst imaginable pain” (score of 100 [100-mm scale])[21].

The Disabilities of the Arm, Shoulder, and Hand (DASH)[22, 23] instrument was employed to assess symptoms and functional status, with a focus on physical function associated with different degrees of disability in the upper extremity. It consists of 30 items about different upper-extremity disabilities and assesses symptoms, physical functions, social functions, and psychological problems, each of which has five possible responses. The DASH ranges from 0–100, where a higher score is a sign of greater upper-extremity disability[24]. The Korean version of the DASH has been validated[22].

Quality of life was measured using the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire, Version 3 (EORTC QLQ-C30) and the Breast Module (EORTC QLQ-BR23)[25–27]. These surveys are specific to cancer patients and include a global health status/quality of life scale, as well as functional and symptom scales. The EORTC QLQ-C30 includes 30 items, most of which have four response levels (not at all, a little, quite a bit, and very much). It includes two questions that address overall health, with seven possible responses (on a scale from very poor to excellent). The EORTC QLQ-BR23 is a breast cancer module of the EORTC QLQ and is considered to be more sensitive and responsive to the functions and symptoms associated with breast cancer. These questionnaires are reliable, valid, sensitive to change, and able to distinguish between patients in different disease stages, and with different performance statuses. The Korean versions of the EORTC QLQ-C30 and EORTC QLQ-BR23 have been validated[26, 27].

Statistical analyses were performed using SPSS, version 20.0 (IBM-SPSS Inc., Chicago, IL, USA). The mean and standard deviation (SD) of demographic and other descriptive variables were calculated. Friedman tests were used to determine whether arm abduction angle was effective for measuring differences in shoulder horizontal abduction. Analysis of variance and Kruskal-Wallis tests were used to assess differences in changes in shoulder range of motion, DASH, pain score, and factors related to quality of life among the three groups. Statistical significance was assessed using p-value of <0.05.

RESULTS

At baseline, there were no significant differences in age (years), BMI (kg/m^2), time since surgery (months), affected side, type of surgery, or method of lymph-node dissection between the three groups (Table 1). The mean (± SD) age (years) was 48.5 ± 6.0, 46.2 ± 6.1, and 44.6 ± 7.5 in groups A, B, and C, respectively. At baseline, the horizontal abduction degree between shoulders differed according to arm abduction angle.

The difference in shoulder horizontal abduction was significantly larger when arms were abducted to 90° or 135° compared with 45° (p=0.023). The mean difference in shoulder horizontal abduction was 14.7 ± 10.5° with the arm abducted to 45°, 22.9 ± 10.1° with the arm abducted to 90°, and 20.3 ± 10.0° with the arm abducted to 135° (Table 2).

There were no significant differences among the three groups in the shoulder range of motion except for the horizontal abduction at baseline and after therapy. Significant differences were found among the three groups for the primary outcome (changes in shoulder horizontal abduction after the stretching program). The changes in shoulder horizontal degree were 10.0 ± 7.8° in group A, 25.7 ± 27.1° in group B, and 23.3 ± 10.8° in group C. The changes in shoulder horizontal abduction were larger in groups B and C than in group A.

There were no statistically significant differences between the changes in the VAS and DASH scores among the three groups. No differences were found among groups for the items reported on the EORTC QLQ-BR23. Similarly, there were no significant differences in the sub-item scores of the EORTC QLQ-C30 and BR23 (Table 3).

DISCUSSION

The findings of the present study suggest that when measuring shoulder horizontal abduction for diagnosing PMT, an arm abduction angle of >90° is more effective. When the arm was abducted to 90° and 135°, the difference in shoulder horizontal abduction between shoulders in breast cancer patients was more prominent than when the arm was abducted to 45°. When the arm was abducted to 45°, the pectoral muscle could not be sufficiently elongated. A shorter pectoral muscle seems to be unsuitable for measuring PMT.

Table 1. Baseline characteristics of the study patients

	Group A (n=11)	Group B (n=11)	Group C (n=10)
Age (years)	48.5 (6.0)	46.2 (6.1)	44.6 (7.5)
BMI (kg/m^2)	22.8 (1.8)	23.5 (2.6)	21.6 (2.7)
Time from surgery (months)	7.9 (5.5)	6.9 (3.8)	5.7 (4.4)
Affected site (dominant hand side:non-dominant side)	6:5	5:6	3:7
Type of surgery (BCO:MRM:other)	5:5:1	5:4:2	4:5:1

Values are expressed as mean (SD) or number.
BMI: body mass index; BCO: breast-conserving operation; MRM: modified radical mastectomy

Table 2. Differences in horizontal abduction between shoulders according to the arm abduction angle when measuring PMT

Differences in horizontal abduction between shoulders	
45° arm abduction*	14.7 (10.5)
90° arm abduction	22.9 (10.1)†
135° arm abduction	20.3 (10.0)†

Values are expressed as mean (SD).
*p<0.05 by Friedman test.
†p<0.025 by Bonferroni correction, compared with a 45° arm abduction.

In addition, when stretching to alleviate PMT, an arm abduction angle >90° may be more effective. The primary outcome of this study—shoulder horizontal abduction limitation—was improved in groups B and C. Although, group A patients also showed improvement in shoulder horizontal abduction, group B and C patients showed greater improvement in this regard. This implies that our 4-week stretching program was effective for improving PMT in breast cancer patients. Moreover, stretching was much more effective when patients stretched the pectoral muscle with the arm abducted to >90°.

In clinical trials, the effects of postoperative physical therapy programs, such as passive mobilization, manual stretching, and strengthening exercises were investigated. Many studies found that exercise program were more effective than no therapy[15)], information about exercise[28–30)] or home exercise programs[31)] for the treatment of pain and impairment of the upper extremity. However, few studies have been conducted to determine the effectiveness of using a stretching exercise program. Only one study, by Lee et al.[32)] investigated the effects of a pectoral stretching exercise program. The stretching program consisted of low-load, prolonged, passive stretching exercises for the pectoral muscles. The arm was positioned at 90° and 135°abduction and was held in an externally rotated position with a 2-kg weight. Each stretch position was held for up to 10 min, twice a day. However, this study found that the pectoral stretching program had not beneficial effects after a 7-month follow-up. The lack of a positive effect is probably related to the fact that many patients did not undergo an axillary dissection or a mastectomy, and radiotherapy of the axilla, which resulted in a decrease in the upper-extremity impairments. A large proportion of the control group exercised during radiotherapy, performing the exercise routines as shown on the postoperative pamphlets, as well as general exercises such as swimming and yoga. However, in our study, the 4-week stretching program was effective for improving PMT in breast cancer patients. Explanations for the different effects in our study compared with the previous study, included differences in content, duration of treatment, and patient characteristics. Therefore, the effects of stretching on breast cancer patients requires further study with a larger sample and with different methods and treatment durations.

There were no significant differences in pain scores, upper-extremity symptoms, and ability to perform common functional activities between our study groups. Moreover, most of the individual items and the global health status and quality of life score were not significantly different among the groups. One explanation for the lack of a relationship between an improvement in the shoulder horizontal abduction degree and the upper-extremity symptoms, function, and quality of life is that there was no long-term follow-up outcome measurement in our study. At the end of the 4-week stretching treatment, an improvement in shoulder horizontal abduction was detected, but it did not lead to an improvement in upper-extremity symptoms, function, or quality of life. A previous study showed that the DASH score had the strongest correlation with shoulder range of motion, including rotation and abduction[33)]. However, no study has revealed a correlation between the presence of PMT and the DASH score. In our current study, an improvement in PMT did not lead to an increase in the DASH score.

This study is the first to evaluate an effective method for stretching of PMT in breast cancer patients. Despite a high prevalence of PMT in breast cancer patients, problems related to pectoral tightness have been overlooked and few studies of PMT were conducted previously. Physicians should be more concerned about PMT in breast cancer patients and investigators should make an effort to evaluate effective stretching methods for PMT.

A previous study measured PMT using the pectoralis minor length test, which is defined by the linear distance from the treatment table to the posterior aspect of the acromion when the subject is in the supine position[7)]. This test was previously described by Sahrmann et al[34)]. However, in our current study, we assessed PMT with one method, as described above. In

Table 3. Changes in shoulder horizontal abduction, VAS, DASH, EORTCQLQ C-30 and EORTC QLQ-BR23 scores in the three groups

	Group A (n=11)	Group B (n=11)	Group C (n=10)
Δ horizontal abduction in affected side*	10.0 (7.8)	25.7 (27.1)†	23.3 (10.8)†
Δ VAS	–1.0 (1.4)	–1.2 (1.7)	–1.8 (1.6)
Δ DASH score	4.5 (10.9)	7.0 (4.6)	5.2 (6.2)
EORTC QLQ-C30			
Δ Global health status/ QoL	7.6 (4.3)	9.3 (4.8)	15.1 (2.8)
Δ Functional scales	8.4 (3.8)	9.8 (4.6)	14.9 (8.2)
Δ Symptom scales	–1.7 (6.9)	–0.85 (1.3)	–1.2 (5.9)
EORTC QLQ-BR23			
Δ Functional scales	0.9 (2.3)	7.4 (18.4)	13.2 (7.6)
Δ Symptom scales	2.4 (4.0)	1.7 (3.1)	2.5 (7.6)

Values are expressed as mean (SD).
*$p<0.05$ by ANOVA test.
†$p<0.025$ by Bonferroni correction, compared with Group A.
VAS: visual analogue scale; DASH: Disability of Arm and Shoulder and Hand; EORTC QLQ-C30: European Organization for Research and Treatment of Cancer Quality of Life Questionnaire; EORTC QLQ-BR23: European Organization for Research and Treatment of Cancer Breast-Cancer-Specific Quality of Life Questionnaire; QoL: quality of life

the absence of definitive diagnostic criteria to rule out pectoralis tightness, various methods for measuring outcomes may be helpful for assessing the effectiveness of stretching for PMT. Another limitation of our study was the small sample size and the lack of long-term follow-up of outcome measurements. In addition, we could not control for patient compliance with our stretching program. Finally, we did not measure other late complications in breast cancer patients, such as myofascial pain syndrome and rotator-cuff disease. Further studies with long-term follow-up and measurement of the occurrence of other disabilities may be needed.

Horizontal abduction differences between shoulders are more prominent when the arms are abducted to 90° or 135°. The appropriate arm abduction angle for measuring horizontal abduction may be >90°. For pectoral muscle stretching, an arm abduction angle>90° may also be effective; however, large-scaled randomized controlled trials are warranted.

Conflict of interest

We certify that no party having a direct interest in the results of the research supporting this article has or will confer a benefit on us or on any organization with which we are associated. The authors declare that they have no competing interests.

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