Support Care Cancer (2016) 24:2047–2057
DOI 10.1007/s00520-015-3005-1

ORIGINAL ARTICLE

Effects of a physical therapy program combined with manual lymphatic drainage on shoulder function, quality of life, lymphedema incidence, and pain in breast cancer patients with axillary web syndrome following axillary dissection

Youngki Cho[1,2] · Junghwa Do[1] · Sunyoung Jung[3] · Ohyun Kwon[2,4] · Jae Yong Jeon[1]

Received: 11 June 2015 / Accepted: 27 October 2015 / Published online: 5 November 2015

Abstract
Purpose The aim of this study was to evaluate the effects of physical therapy (PT) combined with manual lymphatic drainage (MLD) on shoulder function, pain, lymphedema, visible cords, and quality of life (QOL) in breast cancer patients with axillary web syndrome (AWS).
Methods In this prospective, randomized trial, 41 breast cancer patients with visible and palpable cords on the arm and axilla and a numeric rating scale (NRS) pain score of >3 were randomly assigned to PT (3 times/week for 4 weeks; n=20) and PT combined with MLD (5 times/week for 4 weeks; PTMLD; n=21) groups. MLD was performed by a physical therapist and the patients themselves during week 1 and weeks 2–4, respectively. Arm volume, shoulder function (muscular strength; active range of motion; and disabilities of the arm, shoulder, and hand [DASH]); QOL (European Organization for Research and Treatment of Cancer Core and Breast Cancer-Specific QOL questionnaires), and pain (NRS) were assessed at baseline and after 4 weeks of treatment.
Results QOL including functional and symptom aspects, shoulder flexor strength, DASH, and NRS scores were significantly improved in both groups after the 4-week intervention (P<0.05). NRS score and arm volume were significantly lower in the PTMLD group than in the PT group (P<0.05). Lymphedema was observed in the PT (n=6), but not PTMLD, group (P<0.05).
Conclusions PT improves shoulder function, pain, and QOL in breast cancer patients with AWS and combined with MLD decreases arm lymphedema.

Keywords Axillary web syndrome · Breast neoplasms · Physical therapy modalities · Quality of life

Electronic supplementary material The online version of this article (doi:10.1007/s00520-015-3005-1) contains supplementary material, which is available to authorized users.

✉ Ohyun Kwon
kwonoy@yonsei.ac.kr

✉ Jae Yong Jeon
jyjeon71@gmail.com

[1] Department of Rehabilitation Medicine, Asan Medical Center, University of Ulsan College of Medicine, 88, Olympic-Ro 43-Gil, Songpa-gu, 05505 Seoul, South Korea

[2] Department of Physical Therapy, Graduate School, Yonsei University, Wonju, South Korea

[3] Department of Physical Therapy, Graduate School, Hosan University, Gyeongsan, South Korea

[4] Laboratory of Kinetic Ergocise Based on Movement Analysis, Department of Physical Therapy, Graduate School, Yonsei University, 234 Maeji-ri, Heungeop-Myeon, Wonju, Kangwon-Do 220-710, South Korea

Introduction

Axillary web syndrome (AWS) is a common postoperative complication in breast cancer patients. AWS usually occurs 5–8 weeks after surgery and is characterized by visible or palpable cords of subcutaneous tissue in the breast, medial arm, antecubital space, forearm, hand, or chest wall. This syndrome often limits shoulder and elbow range of motion (ROM), causing pain and tightness [1–4]. Previous studies have demonstrated that AWS incidence varies according to the type of axillary surgery (sentinel node lymph node dissection [SLND] or axillary lymph node dissection [ALND]). AWS incidence rates of 20 and 38–72 % have been reported following SLND and ALND in breast cancer patients, respectively [2, 5, 6]. Bergmann et al. [7] reported that the incidence of AWS after breast cancer surgery was 28.1 % and was related to ALND and numbness in the arm after intercostobrachial nerve injury. The pathophysiology of

AWS has not been extensively investigated, with only a few studies reporting AWS as a benign occurrence. AWS is reported to be associated with lymphovenous damage, lymphatic stasis, and tissue injury resulting from the disruption of superficial lymphatics during axillary surgery [8]. A recent study asserted that AWS and the palpable cords were associated with lymphatic origin, and that they are not related with superficial vein thrombosis or with fascial problem as in Mondor's disease [1]. Therefore, further studies of the etiology and pathophysiology of AWS are needed [9].

Currently, there is no definitive treatment for AWS. Nonsteroidal anti-inflammatory drugs (NSAIDs) and physiotherapy including ROM exercises were found not to be effective in relieving early symptoms of AWS in breast cancer patients [2, 10]. However, other studies have suggested the importance of a physical therapy-directed approach in the AWS management [11, 12]. Most breast cancer patients experience acute postoperative pain with minimal daily activity [13]. Postoperative pain can cause anxiety in using the affected arm, which can limit arm movement and consequently result in muscle shortening and decreased muscle activity [14]. Furthermore, acute postoperative pain can become chronic if left untreated, leading to persistent arm and shoulder disability [15]. Some studies have shown that physical therapy can shorten the natural course of AWS by up to 6 to 8 weeks [2, 6, 10]. In addition to physical therapy, manual lymphatic drainage (MLD) may also reduce the development of AWS [16]. Increased clearance is thought to reduce local levels of inflammatory mediators, which are often associated with edema and pain [17]. MLD has been shown to improve blood circulation [18], stimulate the movement of lymphatic and other tissue fluids [18], and promote fluid clearance and tissue softening [19] in patients with athletic injuries. Early stimulation of lymphatic drainage can also modulate pain and inflexibility associated with lymphatic vessel inflammation secondary to surgical injuries [20]. The therapeutic effects of MLD are likely due to the prevention of protein stagnation and inhibition of factors capable of producing lymphatic overload. The effect of MLD in breast cancer patients with AWS remains unknown. The purpose of this study was to compare shoulder function, lymphedema incidence, presence of visible cords, and quality of life between breast cancer patients with AWS receiving physical therapy alone or in combination with MLD. The purpose of this study was to evaluate the effects of physical therapy (PT) combined with MLD on shoulder function, pain, and lymphedema symptoms in comparison to PT only, in breast cancer patients with AWS.

Methods

Study design and patients

This prospective, randomized, controlled trial was conducted at the Department of Rehabilitation Medicine of Asan Medical Center, Seoul, Korea. Patients who visited the rehabilitation medicine department for regular check-up after surgery were recruited. Breast cancer patients with pain over 3 points using the pain rating scale of numeric rating scale (NRS) on upper/lower arm, elbow, and dorsum site in the region of the cording, and visible or palpable cords in the arm or breast at least 4 weeks after breast cancer surgery were included in the analysis. NSAIDs (two times daily) were prescribed for all patients. Patients with lymphedema, acute thrombosis, skin problems such as infection, or musculoskeletal disorders such as low back pain, disk pain, osteoarthritis, rheumatoid arthritis, pectoral muscle tightness, rotator cuff disease, and adhesive capsulitis were excluded. Also, cording only on the chest or lateral thorax and not involving an arm were excluded. A priori power analysis with G*Power ver. 3.1.5. software (Franz Faul, University of Kiel, Germany) was performed to calculate the sample size. The data of a pilot study of eight subjects was used to achieve the effect size of 1.1, the alpha level of 5 %, and the power of 80 %. The calculated sample was 30. Seventy patients were initially enrolled, of which 22 dropped out of the study because of the long hospital commute. The remaining 48 patients were randomized into two intervention groups: PT and PT combined with MLD (PTMLD). Seven patients were unable to complete the final evaluation; therefore, only 41 patients completed the study (Fig. 1). All measurements were taken by one therapist who was blinded. Written consent was obtained from all patients, and ethics approval of the study was obtained from the Asan Medical Center (2014-0551).

Interventions

Physical therapy

Both the PT and PTMLD groups underwent a physical therapy program three times a week for 4 weeks. Physical therapy sessions included a 10-min warm-up and cool-down, which consisted of eight stretching exercises (Online Resource 1), and strengthening exercises. For upper extremity strengthening, participants performed three different pulley exercises 10 times for three sets. For shoulder flexor, shoulder abductor, and elbow flexor strengthening exercises, participants performed three sets of 10 repetitions using a Thera-Band (Hygenic Corporation, Akrin, OH.) Intensity of exercise was 6~8 on the OMNI Resistance which is equivalent to exercise intensity levels ranging from 60 to 80 % of 1RM (24) for active muscle scale, indicating 'somewhat hard'. OMNI Resistance of 0 indicates 'extremely easy' and 10 indicates 'extremely hard'. All exercises were performed under the supervision of a physical therapist. Manual therapy was then performed for 30 min by a skilled physical therapist and involved gentle circular mobilization of identified tight and stiff tissues of the chest wall and antecubital fossa with full hand or

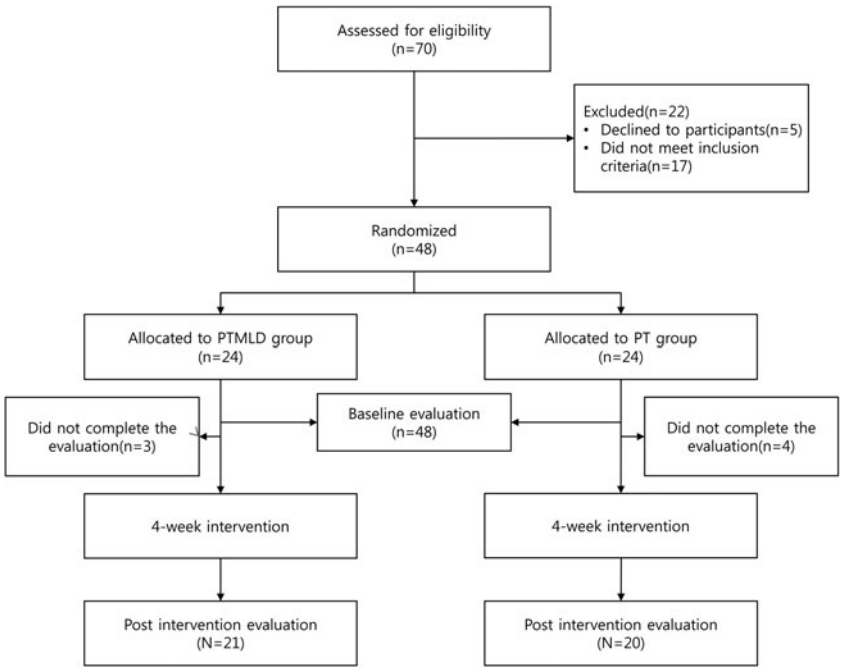

Fig. 1 Flow of participants throughout the trial. *PTMLD* physical therapy combined with manual lymphatic drainage, *PT* physical therapy

two finger contact and longitudinal tissue stretch to the tight cords with the patient's arm in possible range of abduction [19]. Treatment intensity was progressively increased from comfortable to mild discomfort within the tolerable range. In addition, scapular mobilization was used to decrease scapular stiffness. Facing the patient in a side-lying position, the physical therapist pushed underneath the medial border of the scapula and released with the fingertips. The manual therapy program for AWS was performed in the following order: (1) soft tissue mobilization techniques and stretching for tight tissue cords; (2) shoulder abduction, elbow extension, and wrist supination and extension stretching exercises; (3) shoulder girdle mobilization; and (4) passive ROM (PROM) exercises.

Manual lymphatic drainage

MLD was provided by a certified lymphedema therapist. The PTMLD group additionally received 30 min of MLD daily five times a week for 4 weeks. MLD is a light form of circular massage (superficial tissue stretching) and involves stationary circle, pumping and scooping, and rotary movements performed with varying degrees of pressure. MLD was performed by two certified physical therapists (Dr. Vodder Method) during week 1. For weeks 2–4, the patients themselves performed MLD.

Assessments

Arm volume, muscular strength, active ROM (AROM), pain, visible cording, arm disability, and quality of life were evaluated in all patients at baseline and after the 4-week intervention.

Limb volume

Upper limb volumes were calculated from circumference measurements taken at 4-cm intervals from the dorsum of the wrist to the axilla. Volume was calculated from circumference using the established formula [21]. Measurements were taken before and after the 4-week intervention by the same therapist [22]. The diagnostic criterion for lymphedema was a ≥3 % volume increase from baseline in the affected upper limb [23].

Muscular strength

Shoulder flexor and abductor and elbow flexor muscle strength were evaluated by maximal voluntary isometric contraction using a hand-held dynamometer (Power Track II Commander; JTech Medical, Salt Lake City, UT). Shoulder flexor and abductor testing were performed with the patient in a seated position [24]. Muscular strength was tested in the middle of the joint ROM [24, 25], and the maximum contraction values were used. Maximum isometric contraction was measured over a 5-s duration. A pretest was performed before muscular strength assessment. Patients were allowed a 2-min rest between contractions to avoid fatigue. All muscular strength measurements were performed three times, and the average values were used for analysis.

Range of motion

AROM measurements were performed according to the methods described by Norkin and White [26]. AROM was measured in degrees using a digital inclinometer (The

Saunders Group Inc., Chaska, MN). Upper extremity AROM was evaluated in the following positions: supine flexion and supine abduction. AROM measurements of the affected extremity were performed three times, and the average values were used for analysis. Intra-tester reliability for measurement of AROM was established in a pilot study (intraclass correlation coefficient 3,1 = 0.84–1.0).

Quality of life

Quality of life was evaluated using the European Organization for Research and Treatment of Cancer Core Quality of Life Questionnaire (EORTC QLQ-C30; version 3) and Breast Cancer-Specific Quality of Life Questionnaire (EORTC QLQ-BR23). The EORTC QLQ-C30 is a 30-item questionnaire consisting of five functional scales (physical, functional, cognitive, emotional, and social performance), three symptoms scales (fatigue, pain, and nausea and vomiting), and scales of quality of life and overall health status. The BR23 is a 23-item questionnaire consisting of functional and symptomatic scales. These questionnaires have been validated and cross-culturally tested in various cancer populations [27].

Arm disability

The disabilities of the arm, shoulder, and hand (DASH) outcome measure is a 30-item questionnaire designed to assess musculoskeletal disorders of the upper limbs. At least 27 questions must be completed for scoring. DASH scores range from 0 to 100, with higher scores indicating a greater level of disability [28]. The DASH has been reported to be a valid and reliable tool for assessing a variety of arm function [29].

Pain

The NRS assesses pain severity using a single 11-point (0 to 10) scale. A score of 0 indicates no pain, whereas a score of 10 indicates severe pain. NRS-based assessments have been shown to provide valid and reliable assessments in patients with cancer [30, 31]. For each assessment, patients were asked to rate the average pain in their arm during abduction of the shoulder, experienced over the past 7 days.

Cording

The presence of visible and palpable cords in the axilla and arm were assessed by a rehabilitation doctor.

Statistical analysis

Statistical analyses were performed using SPSS version 18.0 software (SPSS Inc., Chicago, IL). Continuous and categorical variables are expressed as means±standard deviations and percentages, respectively. Baseline descriptive statistics were compared using independent *t* tests for continuous data and Fisher's exact test for categorical data. The paired *t* test was used to compare changes in the variables from baseline to week 4 in the two groups. Independent *t* and Fisher's exact tests were applied to compare preintervention to postintervention changes in continuous and categorical variables between the two groups, respectively. A P value <0.05 was considered statistically significant.

Results

Comparison of demographic and clinical characteristics between the PTMLD and PT groups

Occupational status, average exercise frequency, educational status, marital status, economic status, chemotherapy, hormone therapy, disease stage, and surgery method were not significantly different between the PTMLD and PT groups. The average patient age was 46.6 years in the PT group and 50.7 years in the PTMLD group. Neither of these differences were statistically significant (Table 1).

Baseline comparisons between the PTMLD and PT groups

In the baseline evaluation, quality of life including functional status (physical, role, emotional, social, and cognitive functioning) and symptoms (fatigue and pain) was not significantly different between the PTMLD and PT groups. Furthermore, arm and breast symptoms (EORTC QLQ-BR23), muscular strength, ROM, DASH score, arm volume, and NRS score were also not significantly different between the groups (Table 2).

Changes in quality of life, muscular strength, AROM, DASH score, NRS score, and arm volume from baseline to the end of the 4-week treatment

Changes in quality of life, muscular strength, AROM, DASH, NRS, and arm volume from baseline to the end of the 4-week treatment are shown in Table 3. EORTC QLQ-C30 and BR23 results showed a significant improvement in physical, role, emotional, and social functioning; fatigue; pain; and arm and breast symptoms in both the PTMLD and PT groups (P<0.05). Shoulder flexor strength, shoulder flexion and abduction ROM, DASH score, and pain NRS score were also significantly improved in both groups (P<0.05). Arm volume significantly increased over time in the PT group (P<0.05).

Table 1 Baseline demographic and clinical characteristics of the patients

Characteristic	PTMLD group (n=21) No. (%) (unless otherwise stated)	PT group (n=20) No. (%) (unless otherwise stated)	P value
Age (years), mean±SD	46.6±6.8	50.7±9.6	0.098
Occupational status			
Non-employed	4 (19)	2 (10)	0.368
Full-time employed	17 (81)	18 (90)	
BMI			
≥25	6 (28.6)	9 (45)	0.500
<25	15 (71.4)	11 (55)	
Exercise frequency			
≥3 times a week for 30 min	11 (52.4)	6 (30)	0.686
<3 times a week for 30 min	10 (47.6)	14 (70)	
Education level			
High school education	3 (14.3)	8 (40)	0.653
University education	18 (85.7)	12 (60)	
Marital status			
Married	17 (81)	18 (90)	0.632
Single	4 (19)	2 (10)	
Economic status/income			
High	4 (19)	4 (20)	0.222
Medium	15 (71.4)	12 (60)	
Low	2 (9.5)	4 (20)	
Chemotherapy			
Yes	9 (42.9)	11 (55)	0.095
No	12 (57.1)	9 (45)	
Radiotherapy			
Yes	21 (100)	19 (95)	0.200
No	0 (0)	1 (5)	
Hormone therapy			
Yes	14 (66.7)	12 (60)	0.187
No	7 (33.3)	8 (40)	
Cancer stage			
I	5 (23.8)	12 (60)	0.019
III	16 (76.2)	8 (40)	
Lesion			
Rt. side	11 (52.4)	11 (55)	0.867
Lt. side	10 (47.6)	9 (45)	
Type of surgery			
Mastectomy	12 (57.1)	16 (80)	0.289
Lumpectomy	7 (33.3)	3 (15)	
Breast reconstruction	2 (9.6)	1 (5)	

BMI body mass index, *PT* physical therapy, *PTMLD* physical therapy combined with manual lymphatic drainage, *SD* standard deviation

Comparison of the incidence of lymphedema and visible cording between the PTMLD and PT groups after the 4-week treatment

Lymphedema occurred in six patients in the PT group and in none of the patients in the PTMLD group (P<0.05; Table 4). Visible cording was not significantly different between the groups and was present in 28.5 % of patients in the PTMLD group and 35 % patients in the PT group (Table 4).

Comparison of preintervention to postintervention changes in quality of life, muscular strength, DASH score, NRS score, and arm volume between the PTMLD and PT groups

In the postintervention evaluation, the PTMLD group showed a more significant decrease in NRS score compared with the PT group (P<0.05; Table 5). Pain based on the EORTC QLQ-C30 was also significantly decreased in the PTMLD group

Table 2 Baseline comparisons between the PTMLD and PT groups

			PTMLD group (n=21) Mean±SD	PT group (n=20) Mean±SD	P value
EORTC QLQ-C30	Global health status/QOL		50.8±16.4	48.3±21.6	0.682
	Functional scales	Physical functioning	69.8±13.9	63.3±17.9	0.200
		Role functioning	68.2±18.2	55.8±30.7	0.128
		Emotional functioning	66.2±11.9	66.6±19.3	0.936
		Cognitive functioning	73.0±14.4	70.2±24.7	0.668
		Social functioning	64.2±27.0	63.3±24.6	0.906
	Symptom scales	Fatigue	42.3±20.9	43.8±15.9	0.791
		Pain	43.6±24.4	46.6±22.7	0.685
EORTC QLQ-BR23	Symptom scales	Breast symptoms	31.3±21.2	26.2±16.5	0.397
		Arm symptoms	43.3±19.5	42.7±22.9	0.929
Muscular strength (N)	Shoulder flexor		3.8±1.1	3.4±0.8	0.159
	Shoulder abductor		3.9±1.1	3.5±0.8	0.208
	Elbow flexor		5.0±1.0	4.7±0.9	0.423
AROM (degrees)	Shoulder flexion		156.2±9.3	157.3±8.2	0.702
	Shoulder abduction		150.2±11.1	150.3±7.5	0.997
DASH score			24.4±16.8	28.3±22.7	0.527
Arm volume affected region			1895.8±327.2	1847.9±236.1	0.596
Non-affected region			1895.6±326.5	1846.9±237.6	0.589
NRS score			6.2±1.4	6.2±1.4	0.841

AROM active range of motion, *EORTC QLQ-C30* European Organization for Research and Treatment of Cancer Core Quality of Life Questionnaire, *EORTC QLQ-BR23* European Organization for Research and Treatment of Cancer Breast Cancer-Specific Quality of Life Questionnaire, *DASH* disabilities of the arm, shoulder, and hand, *NRS* numeric rating scale, *PT* physical therapy, *PTMLD* physical therapy combined with manual lymphatic drainage, *QOL* quality of life, *SD* standard deviation

compared with the PT group (P<0.05; Table 5). In addition, a significantly greater decrease in arm volume was observed in the PTMLD group (P<0.05; Table 5).

Discussion

In our study, pain and arm volume improved in the PTMLD group compared to the PT group. Our hypothesis of this study was that effects of PTMLD group in aspect of shoulder functions would further decrease pain and lymphedema symptoms in comparison to only PT in breast cancer patients with AWS. To the best of our knowledge, this is the first randomized study to evaluate MLD in breast cancer patients with AWS. We chose to evaluate MLD which was the well-known method for lymphedema treatment based on the study by O'Toole et al. [32], which demonstrated that cording of symptom in AWS was an independent risk factor for arm volume increase in breast cancer patients. Furthermore, AWS is a condition reflecting lymph stasis. MLD has been shown to improve blood circulation [18], enhance the movement of lymphatic and other tissue fluids [18], and promote tissue softening and fluid clearance to different and unblocked lymphatic territories [19]. In addition to MLD, active and passive stretching, soft tissue and cord stretching techniques, and shoulder girdle mobilization were also performed to improve shoulder function. In our results, the cording was not different between the groups. However, MLD affected arm volume in AWS. Our findings support the study by Kepics [33] who recommended MLD, with a 15–20-mmHg compression sleeve if needed, for breast cancer patients with AWS who develop lymphedema.

The pain reduction in the PTMLD group and the difference between the two groups are clinically meaningful. In the present study, patients in the PTMLD group reported significantly less pain than patients in the PT group. AWS patients complained of pain described as a pulling feeling. Previous studies have reported that MLD reduces muscular pain, lymphedema, chronic complex regional pain syndrome, and local levels of inflammatory mediators in subjects with athletic injuries [17]. MLD was also found to relieve pain [33].

Arm lymphedema is the most common complication of breast cancer therapy [18]. Some studies have reported early stimulation of lymphatic drainage is important because inflammation secondary to surgical injuries can render lymphatic drainage difficult [20, 34, 35].

Torres Lacomba et al. [20] suggested that MLD can reduce the risk of lymphedema 2 years after surgery. In our study, lymphedema occurred in the PT group, but not in the

Table 3 Changes in QOL, muscular strength, AROM, DASH score, NRS score, and arm volume from baseline to the end of the 4-week treatment

				Baseline Mean±SD	After 4-week treatment Mean±SD	Mean difference (95 % CI)	*P* value
EORTC QLQ-C30	Global health status/QOL		PTMLD	50.8±16.4	66.2±16.6	−15.48 (−22.40 to −8.56)	0.000
			PT	48.3±21.6	61.2±21.0	12.95 (5.09 to 20.80)	0.003
	Functional scales	Physical functioning	PTMLD	69.8±13.9	79.0±10.2	−9.21 (−14.34 to −4.09)	0.001
			PT	63.3±17.9	73.6±15.4	10.33 (3.97 to 16.69)	0.003
		Role functioning	PTMLD	68.2±18.2	83.3±17.5	−15.09 (−23.02 to −7.16)	0.001
			PT	55.8±30.7	62.5±22.2	6.66 (0.78 to 12.54)	0.028
		Emotional functioning	PTMLD	66.2±11.9	81.3±13.2	−15.09 (−21.26 to −8.91)	0.000
			PT	66.6±19.3	77.1±16.2	10.41 (3.98 to 16.85)	0.003
		Cognitive functioning	PTMLD	73.0±14.4	84.9±12.8	−11.92 (−18.78 to −5.06)	0.002
			PT	70.2±24.7	84.1±14.8	13.92 (3.61 to 24.23)	0.011
		Social functioning	PTMLD	64.2±27.1	85.7±16.1	−21.46 (−34.65 to −8.27)	0.003
			PT	63.3±24.6	76.6±14.7	13.37 (2.13 to 24.60)	0.022
	Symptom scales	Fatigue	PTMLD	42.3±20.9	23.8±20.9	18.50 (10.61 to 26.38)	0.000
			PT	43.8±15.9	30.5±17.2	−13.32 (−25.19 to −1.44)	0.030
		Pain	PTMLD	43.6±24.4	13.5±14.5	30.15 (23.10 to 37.19)	0.000
			PT	46.6±22.7	30.0±16.8	−16.66 (−24.25 to −9.06)	0.000
EORTC QLQ-BR23	Symptom scales	Breast symptoms	PTMLD	31.3±21.2	10.7±11.5	20.63 (12.44 to 28.82)	0.000
			PT	26.3±16.9	8.8±14.3	−17.53 (−25.66 to −9.40)	0.000
		Arm symptoms	PTMLD	43.3±19.5	23.3±15.7	20.07 (12.47 to 27.66)	0.000
			PT	42.7±22.9	19.4±15.6	−23.31 (−34.47 to −12.14)	0.000
Muscular strength (N)	Shoulder flexor		PTMLD	3.8±1.1	4.0±1.0	−0.14 (−0.27 to −0.01)	0.028
			PT	3.4±0.8	3.5±0.8	0.13 (0.02 to 0.23)	0.023
	Shoulder abductor		PTMLD	3.9±1.1	4.0±0.9	−0.1 (−0.25 to 0.04)	0.153
			PT	3.5±0.8	3.7±0.8	0.18 (0.04 to 0.31)	0.013
	Elbow flexor		PTMLD	4.9±1.0	5.1±0.8	−0.13 (−0.38 to 0.11)	0.260
			PT	4.7±0.9	4.7±0.8	−0.02 (−0.15 to 0.11)	0.765
AROM (degrees)	Shoulder flexion		PTMLD	156.2±9.3	180.0±0.0	−23.80 (−28.06 to −19.55)	0.000
			PT	157.3±8.2	180.0±0.0	22.75 (18.91 to 26.58)	0.000
	Shoulder abduction		PTMLD	150.2±11.1	180.0±0.0	−29.76 (−34.82 to −24.69)	0.000
			PT	150.3±7.5	180.0±0.0	29.75 (26.23 to 33.26)	0.000

Table 3 (continued)

		Baseline Mean±SD	After 4-week treatment Mean±SD	Mean difference (95 % CI)	*P* value
DASH score	PTMLD	24.4±16.8	15.7±10.6	8.66 (4.48 to 12.83)	0.000
	PT	28.3±22.7	14.2±9.8	−14.11 (−21.28 to −6.93)	0.001
Arm volume	PTMLD	1895.8±327.2	1894.7±326.7	1.09 (−0.38 to 2.57)	0.139
	PT	1847.9±236.1	1869.7±242.8	21.75 (1.58 to 41.91)	0.036
NRS score	PTMLD	6.2±1.4	1.5±1.0	4.76 (4.01 to 5.42)	0.000
	PT	6.2±1.4	2.6±1.3	−3.6 (−4.11 to −3.08)	0.000

AROM active range of motion, *EORTC QLQ-C30* European Organization for Research and Treatment of Cancer Core Quality of Life Questionnaire, *EORTC QLQ-BR23* European Organization for Research and Treatment of Cancer Breast Cancer-Specific Quality of Life Questionnaire, *DASH* disabilities of the arm, shoulder, and hand, *NRS* numeric rating scale, *PT* physical therapy, *PTMLD* physical therapy combined with manual lymphatic drainage, *QOL* quality of life, *SD* standard deviation, *CI* confidence interval

PTMLD group. Six of the 20 patients in the PT group developed lymphedema after 4 weeks. The affected arm had 3 % difference in volume and patients were diagnosed secondary lymphedema by using lymphoscintigraphic findings, which showed decreased function of the affected axilla lymph nodes. Three of them had increased uptake through dermal backflow. Patients in the PT group also showed a significant increase in arm volume from baseline to week 4 of treatment. Reported lymphedema incidence rates range from 13 to 65 % among breast cancer survivors, depending on the diagnostic criteria used [36, 37]. Our 33.3 % lymphedema incidence rates consistent with previous reports. Because the PTMLD group did not have increase of arm volume, we think our intervention did not cause lymphedema. Also, there were no previous studies that demonstrate physical therapy can cause lymphedema in AWS.

AWS usually occurs in the early postoperative period after breast cancer surgery and is a painful condition that limits daily life functioning. Shoulder abduction is particularly painful in patients with AWS. The present study included patients at least 4 weeks after surgery. And most of them were included at early periods after surgery. The tendency of patients to protect the surgical area and AWS-induced pain can progressively limit shoulder mobility. Previous studies have reported that AWS resolves spontaneously within 3 months [2, 10]. However, during this period of time, changes in shoulder girdle movement and muscle imbalances may occur. We found that AROM (flexion, abduction) of the shoulder was significantly improved in both the PTMLD and PT groups following treatment. In addition, the physical therapy program increased shoulder flexor muscle strength and DASH score. Josenhans [38] demonstrated that symptom improvement including decreased pain, restoration of full shoulder ROM, and increased shoulder function could be attained within six physical therapy sessions. In our study, physical therapy restored shoulder ROM and improved muscular strength in all patients. Most studies of physical therapy in breast cancer patients with AWS have been case reports. Nonetheless, these studies suggest that physical therapy is a quick and effective method to resolve shoulder disorders [11, 12]. Fourie and Robb [39] reported the case of a woman who developed AWS 22 days following axillary dissection. Physiotherapy with rotatory movements and stretching of the restricted tissue resulted in the achievement of premorbid ROM within 3 weeks. Furthermore, pain and visible cords had completely resolved after 16 weeks of therapy. As this case report, physical therapy can shorten the natural course of AWS by up to 3 months.

Breast cancer patients commonly experience symptoms of fatigue, anxiety, and depression. Breast cancer and its

Table 4 Comparison of the incidence of lymphedema and visible cording between the PTMLD and PT groups after 4 weeks of treatment

	PTMLD group (*n*=21) Mean±SD	PT group (*n*=20) Mean±SD	Difference	*P* value
Visible cords (yes/no)	6/15	7/13	1	0.658
Lymphedema (yes/no)	0/21	6/14	6	0.009

PT physical therapy, *PTMLD* physical therapy combined with manual lymphatic drainage, *SD* standard deviation

Table 5 Comparison of preintervention to postintervention changes in QOL, muscular strength, AROM, DASH score, NRS score, and arm volume between the PTMLD and PT groups

			PTMLD group (n=21) Mean±SD	PT group (n=20) Mean±SD	Mean difference (95 % CI)	P value
EORTC QLQ-C30	Global health status/QOL		15.5±15.2	13.0±16.8	2.53 (−7.60 to 12.66)	0.615
	Functional scales	Physical functioning	9.2±11.3	10.3±13.6	−1.11 (−9.03 to 6.79)	0.776
		Role functioning	15.1±17.4	6.7±12.6	8.43 (−1.15 to 18.01)	0.085
		Emotional functioning	15.1±13.6	10.4±13.8	4.67 (−3.96 to 13.30)	0.281
		Cognitive functioning	11.9±15.1	13.9±22.0	−2.00 (−14.04 to 10.04)	0.735
		Social functioning	21.5±29.0	13.3±24.0	8.09 (−8.68 to 24.88)	0.337
	Symptom scales	Fatigue	−18.5±17.3	−13.3±25.4	−5.18 (−19.03 to 8.67)	0.448
		Pain	−30.2±15.5	−16.7±16.2	−13.49 (−23.52 to −3.46)	0.010
EORTC QLQ-BR23	Symptom scales	Breast symptoms	−20.6±18.0	−17.9±16.5	−2.72 (−13.62 to 8.17)	0.616
		Arm symptoms	−20.1±16.7	−23.3±23.9	3.23 (−9.89 to 16.36)	0.616
Muscular strength (N)		Shoulder flexor	0.1±0.3	0.1±0.2	0.01 (−0.14 to 0.18)	0.831
		Shoulder abductor	0.1±0.3	0.2±0.3	−0.07 (−0.27 to 0.12)	0.442
		Elbow flexor	0.1±0.5	0.0±0.3	0.15 (0.11 to 0.43)	0.259
AROM (degrees)		Shoulder flexion	23.8±9.3	22.8±8.2	1.06 (−4.48 to 6.60)	0.702
		Shoulder abduction	29.8±11.1	29.8±7.5	0.01 (−5.98 to 6.00)	0.997
DASH score			−8.7±9.2	−14.1±15.3	5.44 (−2.65 to 13.54)	0.180
Arm volume			−1.1±3.3	21.8±43.1	−22.84 (−41.90 to −3.78)	0.029
NRS score			−4.8±1.4	−3.6±1.1	−1.16 (−1.97 to −0.34)	0.006

AROM active range of motion, *EORTC QLQ-C30* European Organization for Research and Treatment of Cancer Core Quality of Life Questionnaire, *EORTC QLQ-BR23* European Organization for Research and Treatment of Cancer Breast Cancer-Specific Quality of Life Questionnaire, *DASH* disabilities of the arm, shoulder, and hand, *NRS* numeric rating scale, *PT* physical therapy, *PTMLD* physical therapy combined with manual lymphatic drainage, *QOL* quality of life, *SD* standard deviation, *CI* confidence interval

treatment pose many challenges to physical, emotional, mental, and social well-being and negatively impact quality of life. In particular, limited shoulder ROM negatively influences functional capacity and quality of life [40–42]. Breast cancer patients with musculoskeletal pain demonstrate significantly lower health-related quality of life including physical and mental functioning [41]. Therefore, QoL is an important patient-centered outcome addressed by PT in breast cancer patients. Indeed, quality of life was improved in both the PTMLD and PT groups in our study. The physical therapy program improved physical, role, emotional, and social functioning and fatigue in the study population. Furthermore, exercise had a positive effect on breast and arm symptoms. Our physical therapy program focused on shoulder stretching exercises. We believe that restoration of shoulder function and decreased pain contributed to the positive outcomes of the physical therapy program on quality of life. Previous studies have shown that yoga programs also improve stress, fatigue, emotional functioning, pain, vitality, and quality of life in cancer patients [42, 43].

Our study had several limitations. First, we could not discern the natural course of lymphedema development and AWS. The lack of a true, no-treatment, control group prevented us from observing the natural course of AWS. A no-treatment control group was not included because we considered it unethical to withhold treatment from patients with

AWS. Second, we did not consider of change of arm volume by assessing muscle hypertrophy through imaging but relied solely on circumferential assessment, However, this is the commonly used clinical assessment so has clinical relevance. Third, the PT MLD group received additional PT time and attention during the first week, which could be a potential confounder and may have had an impact on reports of pain. Finally, patient compliance in taking prescribed NSAIDs was not monitored. In conclusion, our findings provide evidence that a physical therapy program combined with MLD is an effective strategy to improve pain, shoulder function, and QOL in breast cancer patients with AWS. Physical therapy can also contribute to the prevention of lymphedema and shoulder joint contracture due to pain.

Compliance with Ethical Standards

Conflict of interest None of the authors has any financial support or relationship with regard to the submitted manuscript that might be construed as a conflict of interest. All authors have full control of all primary data and agree to allow the journal to review the data if requested.

References

1. Leduc O, Fumiere E, Banse S, Vandervorst C, Clement A, Parijs T, Wilputte F, Maquerlot F, Ezquer Echandia M, Tinlot A, Leduc A (2014) Identification and description of the axillary web syndrome (AWS) by clinical signs, MRI and US imaging. Lymphology 47: 164–176
2. Leidenius M, Leppanen E, Krogerus L, von Smitten K (2003) Motion restriction and axillary web syndrome after sentinel node biopsy and axillary clearance in breast cancer. Am J Surg 185:127–130
3. Ferreira Rezende L, Laier Franco R, Costa Gurgel MS (2005) Axillary web syndrome: practical implications. Breast J 11:531. doi:10.1111/j.1075-122X.2005.00169.x
4. Pappo I, Wasserman I, Stahl-Kent V, Sandbank J, Halevy A (2004) Mondor's disease of the axilla: a rare complication of sentinel node biopsy. Breast J 10:253–255. doi:10.1111/j.1075-122X.2004.21438.x
5. Bergmann A, Mattos IE, Pedrosa E, Nogueira EA, Koifman R (2007) Axillary web syndrome after lymph node dissection: results for 1004 breast cancer patients. Lymphology 40:198–203
6. Torres Lacomba M, Mayoral Del Moral O, Coperias Zazo JL, Yuste Sanchez MJ, Ferrandez JC, Zapico Goni A (2009) Axillary web syndrome after axillary dissection in breast cancer: a prospective study. Breast Cancer Res Treat 117:625–630. doi:10.1007/s10549-009-0371-8
7. Bergmann A, Mendes VV, de Almeida DR, do Amaral ESB, da Costa Leite Ferreira MG, Fabro EA (2012) Incidence and risk factors for axillary web syndrome after breast cancer surgery. Breast Cancer Res Treat 131:987–992. doi:10.1007/s10549-011-1805-7
8. Rashtak S, Gamble GL, Gibson LE, Pittelkow MR (2012) From furuncle to axillary web syndrome: shedding light on histopathology and pathogenesis. Dermatology 224:110–114. doi:10.1159/000337210
9. Koehler LA, Blaes AH, Haddad TC, Hunter DW, Hirsch AT, Ludewig PM (2015) Movement, function, pain, and postoperative edema in axillary web syndrome. Phys Ther. doi:10.2522/ptj.20140377
10. Moskovitz AH, Anderson BO, Yeung RS, Byrd DR, Lawton TJ, Moe RE (2001) Axillary web syndrome after axillary dissection. Am J Surg 181:434–439
11. Giuliano AE, Haigh PI, Brennan MB, Hansen NM, Kelley MC, Ye W, Glass EC, Turner RR (2000) Prospective observational study of sentinel lymphadenectomy without further axillary dissection in patients with sentinel node-negative breast cancer. J Clin Oncol 18:2553–2559
12. Wei P, Zhu L, Chen K, Jia W, Hu Y, Su F (2013) Axillary web syndrome following secondary breast-conserving surgery: a case report. World J Surg Oncol 11:8. doi:10.1186/1477-7819-11-8
13. Katz J, Poleshuck EL, Andrus CH, Hogan LA, Jung BF, Kulick DI, Dworkin RH (2005) Risk factors for acute pain and its persistence following breast cancer surgery. Pain 119:16–25. doi:10.1016/j.pain.2005.09.008
14. Shamley DR, Srinanaganathan R, Weatherall R, Oskrochi R, Watson M, Ostlere S, Sugden E (2007) Changes in shoulder muscle size and activity following treatment for breast cancer. Breast Cancer Res Treat 106:19–27. doi:10.1007/s10549-006-9466-7
15. Karki A, Simonen R, Malkia E, Selfe J (2005) Impairments, activity limitations and participation restrictions 6 and 12 months after breast cancer operation. J Rehabil Med 37:180–188. doi:10.1080/16501970410024181
16. Ferrandez JC, Doyer M, Serin D, De Rauglaudre G (2007) Thromboses lymphatiques superficielles. In: Petiot S, Hérisson C, Pélissier J (eds) Cancer du sein et médecine de rééducation. Elsevier Masson, Issy-les-Moulineaux, pp 119–128
17. Vairo GL, Miller SJ, McBrier NM, Buckley WE (2009) Systematic review of efficacy for manual lymphatic drainage techniques in sports medicine and rehabilitation: an evidence-based practice approach. J Man Manip Ther 17:e80–e89
18. Goats GC (1994) Massage—the scientific basis of an ancient art: part 2. Physiological and therapeutic effects. Br J Sports Med 28: 153–156
19. Harris R, Piller N (2003) Three case studies indicating the effectiveness of manual lymph drainage on patients with primary and secondary lymphedema using objective measuring tools. J Bodyw Mov Ther 7:213–221. doi:10.1016/s1360-8592(03)00036-6
20. Torres Lacomba M, Yuste Sanchez MJ, Zapico Goni A, Prieto Merino D, Mayoral del Moral O, Cerezo Tellez E, Minayo Mogollon E (2010) Effectiveness of early physiotherapy to prevent lymphoedema after surgery for breast cancer: randomised, single blinded, clinical trial. BMJ 340:b5396. doi:10.1136/bmj.b5396
21. Kang Y, Jang DH, Jeon JY, Lee SJ, Jeong SY, Shin DI, Kim HJ (2012) Pressure monitoring of multilayer inelastic bandaging and the effect of padding in breast cancer-related lymphedema patients. Am J Phys Med Rehabil 91:768–773. doi:10.1097/PHM.0b013e3182643c36
22. Taylor R, Jayasinghe UW, Koelmeyer L, Ung O, Boyages J (2006) Reliability and validity of arm volume measurements for assessment of lymphedema. Phys Ther 86:205–214
23. Stout Gergich NL, Pfalzer LA, McGarvey C, Springer B, Gerber LH, Soballe P (2008) Preoperative assessment enables the early diagnosis and successful treatment of lymphedema. Cancer 112: 2809–2819. doi:10.1002/cncr.23494
24. Ford-Smith CD, Wyman JF, Elswick RK Jr, Fernandez T (2001) Reliability of stationary dynamometer muscle strength testing in community-dwelling older adults. Arch Phys Med Rehabil 82: 1128–1132. doi:10.1053/apmr.2001.24291
25. Bohannon RW, Andrews AW (1987) Interrater reliability of hand-held dynamometry. Phys Ther 67:931–933

26. Norkin CC, White DJ (1995) Measurement of joint motion: a guide to goniometry. F.A. Davis, Philadelphia
27. Yun YH, Park YS, Lee ES, Bang SM, Heo DS, Park SY, You CH, West K (2004) Validation of the Korean version of the EORTC QLQ-C30. Qual Life Res 13:863–868
28. Solway S, Institute for Work & Health, American Academy of Orthopaedic Surgeons (2002) The DASH outcome measure user's manual. Institute for work & health. American Academy of Orthopaedic Surgeons, Toronto
29. Beaton DE, Katz JN, Fossel AH, Wright JG, Tarasuk V, Bombardier C (2001) Measuring the whole or the parts? Validity, reliability, and responsiveness of the disabilities of the arm, shoulder and hand outcome measure in different regions of the upper extremity. J Hand Ther 14:128–146
30. Buchanan DR, O'Mara AM, Kelaghan JW, Minasian LM (2005) Quality-of-life assessment in the symptom management trials of the national cancer institute-supported community clinical oncology program. J Clin Oncol 23:591–598. doi:10.1200/JCO.2005.12.181
31. Butt Z, Wagner LI, Beaumont JL, Paice JA, Peterman AH, Shevrin D, Von Roenn JH, Carro G, Straus JL, Muir JC, Cella D (2008) Use of a single-item screening tool to detect clinically significant fatigue, pain, distress, and anorexia in ambulatory cancer practice. J Pain Symptom Manag 35:20–30. doi:10.1016/j.jpainsymman.2007.02.040
32. O'Toole J, Miller CL, Specht MC, Skolny MN, Jammallo LS, Horick N, Elliott K, Niemierko A, Taghian AG (2013) Cording following treatment for breast cancer. Breast Cancer Res Treat 140:105–111. doi:10.1007/s10549-013-2616-9
33. Kepics J (2007) Treatment of axillary web syndrome: a case report using manual techniques http://www.vodderschool.com/treatment_of_axillary_web_syndrome. Accessed 26 May 2015
34. Devoogdt N, Christiaens MR, Geraerts I, Truijen S, Smeets A, Leunen K, Neven P, Van Kampen M (2011) Effect of manual lymph drainage in addition to guidelines and exercise therapy on arm lymphoedema related to breast cancer: randomised controlled trial. BMJ 343:d5326. doi:10.1136/bmj.d5326
35. Sarri AJ, Moriguchi SM, Dias R, Peres SV, da Silva ET, Koga KH, Zucca Matthes AG, Dos Santos MJ, Da ET R, Haikel RL (2010) Physiotherapeutic stimulation: early prevention of lymphedema following axillary lymph node dissection for breast cancer treatment. Exp Ther Med 1:147–152. doi:10.3892/etm_00000024
36. Gartner R, Jensen MB, Kronborg L, Ewertz M, Kehlet H, Kroman N (2010) Self-reported arm-lymphedema and functional impairment after breast cancer treatment—a nationwide study of prevalence and associated factors. Breast 19:506–515. doi:10.1016/j.breast.2010.05.015
37. Kwan ML, Darbinian J, Schmitz KH, Citron R, Partee P, Kutner SE, Kushi LH (2010) Risk factors for lymphedema in a prospective breast cancer survivorship study: the pathways study. Arch Surg 145:1055–1063. doi:10.1001/archsurg.2010.231
38. Josenhans E (2007) Physiotherapeutic treatment for axillary cord formation following breast cancer surgery. Pt_Zeitschrift für Physiotherapeuten 59:868–878
39. Fourie WJ, Robb KA (2009) Physiotherapy management of axillary web syndrome following breast cancer treatment: discussing the use of soft tissue techniques. Physiotherapy 95:314–320. doi:10.1016/j.physio.2009.05.001
40. Martins da Silva RC, Rezende LF (2014) Assessment of impact of late postoperative physical functional disabilities on quality of life in breast cancer survivors. Tumori 100:87–90. doi:10.1700/1430.15821
41. Olufade T, Gallicchio L, MacDonald R, Helzlsouer KJ (2015) Musculoskeletal pain and health-related quality of life among breast cancer patients treated with aromatase inhibitors. Support Care Cancer 23:447–455. doi:10.1007/s00520-014-2364-3
42. Banasik J, Williams H, Haberman M, Blank SE, Bendel R (2011) Effect of Iyengar yoga practice on fatigue and diurnal salivary cortisol concentration in breast cancer survivors. J Am Acad Nurse Pract 23:135–142. doi:10.1111/j.1745-7599.2010.00573.x
43. Danhauer SC, Mihalko SL, Russell GB, Campbell CR, Felder L, Daley K, Levine EA (2009) Restorative yoga for women with breast cancer: findings from a randomized pilot study. Psychooncology 18:360–368. doi:10.1002/pon.1503