Effects of Music-based Rhythmic Exercise Program of Upper and Lower Extremities on Lymphedema, Muscle Strength, and Physical Function in Post-mastectomy Women

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Purpose This study aimed to explore the effects of a music-based rhythmic exercise program of upper and lower extremities on lymphedema, muscle strength, and physical function in post-mastectomy. ***Methods*** Fourteen women who underwent mastectomy volunteered to participate. All participants underwent a music-based rhythmic exercise program while walking on a treadmill, which consisted of four upper-limb exercises with dumbbells. The intervention was performed for an average of 1 hour, 5 times a week for 8 weeks (a total of 40 sessions). Outcome measures included the extent of lymphedema, shoulder muscle strength, shoulder pain disability index, and a 6-min walk test. ***Results*** Outcome measures included the extent of lymphedema, shoulder muscle strength, shoulder pain disability index, and a 6-min walk test. There were significantly improved scores for all the parameters after the intervention ($p<0.05$). ***Conclusion*** This finding suggests that a music-based rhythmic exercise program combined with treadmill walking may favorably improve lymphedema, shoulder muscle strength, shoulder pain and disability, and walking endurance in post-mastectomy women.

Key Words Function, Mastectomy, Rhythmic exercise, Strength, Treadmill

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Ⅰ. Introduction

Early detection and treatment of breast cancer have significantly increased the survival rate of patients in recent years.[1)] Mastectomy is a surgical procedure to remove cancerous breast lesions and is successful in improving the treatment effects. Despite its benefits, lymph nodes and surrounding tissues in the axillary area are eliminated during surgery, leading to physical complications. For example, pain, abnormal sensations, limited movement, muscle weakness, fatigue, and lymphedema may develop after mastectomy.[2,3)] In addition, these problems result in psychosocial and emotional distress and make daily activities difficult, decreasing the quality of life and confidence in performing daily activities.[4)] Therefore, the therapeutic focus should be alleviating the physical symptoms post-mastectomy.

Various exercises are commonly used to prevent secondary problems associated with mastectomy. Previous studies have reported the benefits of resistance exercise,[5)] aerobic,[6)] physical training,[3)] and music therapy[7)] in boosting the effects of cancer treatment. In general, inactivity and sedentary lifestyles contribute to increased mortality and recurrence of cancer;[8)] therefore, exercise and physical activity are crucial to cancer rehabilitation. Accordingly, treadmill walking has been widely used to facilitate physical activity in clinical practice, aiming to improve the cardiopulmonary fitness of cancer survivors.

Breast cancer survivors recognize that exercise and physical activity are necessary to manage potential problems related to mastectomy; however, over time, their motives or willingness gradually decrease, which makes it difficult for them to maintain exercise adherence and meet current international physical activity guidelines.[9)] This suggests that exercises with therapist supervision may be more advantageous in promoting training effects in the clinical setting. Moreover, music-based rhythmic exercises have been considered a

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good way to encourage cancer survivors' interest and active participation in exercise in long-term care. While listening to their favorite music, breast cancer survivors can undergo auditory-motor synchronization by integrating their movements into the music's rhythm and tempo.[10] This promotes the benefits of exercise therapy.

After mastectomy, clinicians have emphasized effective, easy, and time-saving interventions to find the best solution to cover the physical complications caused by deconditioning. This supports the necessity of integrating many factors of useful interventions in clinical practice. However, to our knowledge, there has been insufficient interest in such attempts. Therefore, this study aimed to explore the effects of music-based rhythmic exercise program of upper and lower extremities on lymphedema, muscle strength, and physical function in post-mastectomy women.

II. Methods

1. Participants

This study used a pre- and post-test design. Fourteen women who underwent mastectomy volunteered to participate in this study. The participants were patients receiving outpatient therapy at W university hospital located in I city, recruited through a research poster announcement. The inclusion criteria for this study were as follows:[11] (1) unilateral mastectomy due to breast cancer; (2) over three months after mastectomy; and (3) no orthopedic, neurological, cardiorespiratory, or psychological impairments. Initially, twenty participants were included in this study; however, six participants were excluded. The final analysis included data collected from 14 participants(Figure 1). All participants were informed about the study procedure and safety before participation and signed a written informed consent form. The demographic and clinical characteristics of the participants are presented in Table 1.

Table 1. Demographic and clinical characteristics

Variables	Participants (n=14)
Age (year)	52.93±4.78
Onset (month)	19.99±13.69
Height (cm)	158.56±4.13
Weight (kg)	63.47±7.39
BMI (kg/m^2)	25.23±2.71
Surgical side (right/left)	5/9

Values are presented as mean±standard deviation, BMI: Body mass index.

2. Research procedure

Participants performed a rhythmic exercise program during treadmill walking(Table 2). The slope and speed of the treadmill were established according to a

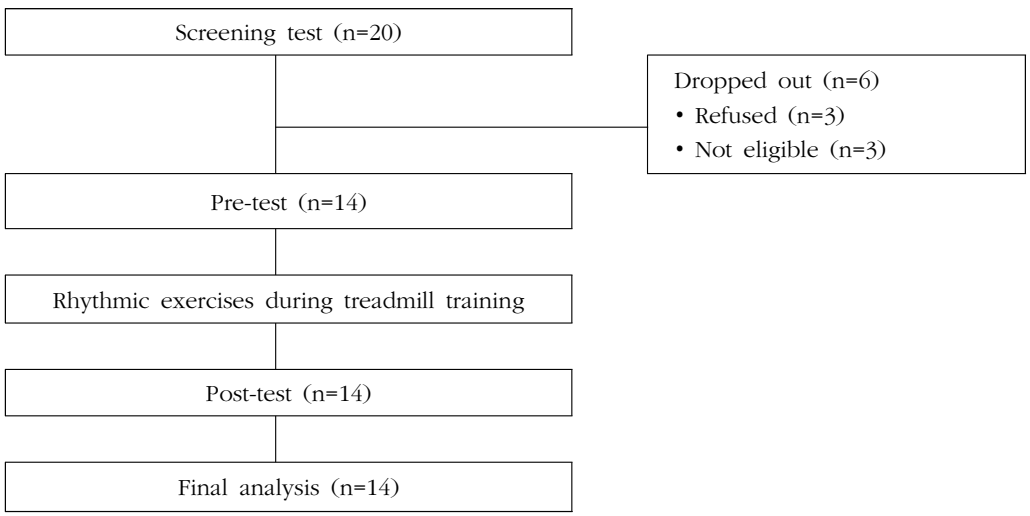

Figure 1. Study flow

Table 2. Rhythmic exercise program

Biceps curl	Starting position: Stand with both arms at sides, then alternately swing arms with elbows fully flexed in front of body while walking on the treadmill. Repetitions: 5 sets of 8-12 repetitions	
Shoulder press	Starting position: Stand with shoulder and elbow flexed at 90˚, then alternately extend each arm toward the ceiling while walking on the treadmill. Repetitions: 5 sets of 8-12 repetitions	
Lateral arm raise	Starting position: Stand holding dumbbells with an external rotation of arms. Raise arms until shoulders are horizontal. Repetitions: 5 sets of 8-12 repetitions	
Triceps extension	Starting position: Stand with shoulders flexed at 90˚ and elbows fully flexed, then alternately extend elbows toward the ceiling while walking on the treadmill. Repetitions: 5 sets of 8-12 repetitions	

modified version of the Balke protocol.[12] At the start of training, the speed was 3 mph, and the slope was 0%. After 2 min, the slope was increased by 1% every 2 min. The rhythmic exercise program consisted of a biceps curl, shoulder press, spread arm, and triceps extension exercises. Four movements were performed while walking to music on the treadmill. Rhythmic exercise is an adjustment of body movements to various rhythms and listening to regular beats was reported that the auditory cortex of processes sound and the motor cortex of movement control were co-activated that auditory-motor synchronization ability is

improved.[13] In this study, the coordination movements of the left arm and the right leg, the right arm and the left leg were required, and the simultaneous movements of both arms were taught to perform when the left leg came forward. Each exercise was performed for 10 min, and the participants had a 2-min rest interval between exercises. To encourage interest and active participation in the training, the music to be played was chosen based on the patient's preference. pop songs (folk and country genres) were chosen with 4/4 beats and Andante and Allegro tempo, applied at a volume of 60 ± 5 dB.[14] Also, to increase training effort, participants performed the exercises with a dumbbell of 0.5–2 kg weight, which was determined using 10 repetition maximum.[15] The participants were allowed to wear a compression garment to prevent sudden lymphedema of the affected arm. Before and after the training, the participants experienced simple movements and stretching of the trunk and upper and lower limbs for 5 min as a warm-up and cool-down exercises, respectively. The training was performed for an average of 1 hour a day, 5 times a week for 8 weeks.

3. Evaluation tool

(1) Extent of lymphedema

The extent of lymphedema was evaluated using a tape measure(KMC-330-20M, Komelon Corp, Busan) with a precision of 1 mm. Circumferences at the wrist and elbow joints and 10 cm below and above the elbow joint on the affected side were measured in the supine position.[16] Data were averaged over triplicate trials.

(2) Muscle strength of the shoulder

Strength was measured with the BTE-Primus(BTE Primus RS, BTE Technologies Inc, Chicago), involving the shoulder's flexor, extensor, and external and internal rotators on the surgical and non-surgical sides. After adjusting the measurement axis at the height of the shoulder of each participant, they performed maximal isometric contraction in the direction of each movement by holding a fixed bar of the device. Data were averaged over triplicate trials with a 2-min rest interval. Strength measurements using this device have been reported to be reliable (r=0.97) and valid (r=0.96) for clinical use.[17]

(3) Shoulder pain and disability index (SPADI)

The SPADI is widely used in clinical practice to evaluate shoulder pain and dysfunction levels in individuals with shoulder impairments. The SPADI consists of 13 items: 5 items on the pain scale and 8 items on the disability scale. Each item of the SPADI is a 10-point Liker scale, with a 0-point indicating 'no pain' and 10-point indicating 'the worst pain imaginable' for the pain scale, and a 0-point indicating 'no difficulty' and 10-point indicating 'so difficult it requires help' for the disability scale. The SPADI has been recognized as having excellent reliability(r=0.99).[18]

(4) 6–min walk test (6 MWT)

The 6 MWT is a simple cardiopulmonary functional test modality. Participants were shuttled between a 30-m indoor corridor, and the distance taken during 6-min walking was measured. Participants were asked to walk as far as possible at their own pace and allowed rest if needed.[19] Data were averaged over triplicate trials with a 2-min rest interval. The 6 MWT has been reported to be highly reliable for clinical use (ICC=0.91).[20]

4. Analysis method

Data were statistically analyzed using Windows SPSS version 25.0 (SPSS Inc., Chicago). Data are presented as the mean and standard deviation. The Kolmogorov–Smirnov test was used to identify the normal distribution of the data. A paired *t*-test was used to compare the pre-and post-test values. Statistical significance was set at $p < 0.05$.

Ⅲ. Results

All parameters showed significantly improved post-test values compared to pre-test values ($p<0.05$) (Table 3) (Table 4). After the intervention, the extent of lymphedema decreased by 5.63% and 4.96% at wrist and

Table 3. Comparison of pre- and post-test values in the extent of lymphedema

	Pre-test	Post-test	t
Extent of lymphedema (cm)			
Wrist	17.75±1.55	16.75±0.96	4.27*
10 cm below elbow	25.86±2.91	23.75±2.62	9.43*
Elbow	27.21±2.24	25.86±2.03	5.73*
10 cm above elbow	30.11±2.63	28.86±1.99	3.28*
SPADI (scores)			
Pain	29.29±8.80	16.07±10.45	3.62*
Disability	29.29±12.72	18.36±10.56	2.47*
Total	58.57±18.95	35.14±19.01	3.27*

Values are presented as mean ± standard deviation. *p<0.05, SPADI: Shoulder pain and disability index

Table 4. Comparison of pre- and post-test values in shoulder strength

	Pre-test	Post-test	t
Flexors			
Surgical side	16.74±4.30	22.50±6.39	-4.95*
Non-surgical side	20.76±5.50	24.09±3.80	-2.65*
Extensors			
Surgical side	20.58±5.28	25.55±5.39	-4.31*
Non-surgical side	23.85±6.77	27.76±8.06	-2.98*
External rotators			
Surgical side	12.51±3.21	16.98±3.52	-6.63*
Non-surgical side	14.78±4.97	17.78±4.15	-3.38*
Internal rotators			
Surgical side	16.33±4.44	21.85±4.96	-5.48*
Non-surgical side	18.80±5.54	23.23±4.9.	-3.13*
6MWT (m)	488.42±55.82	547.36±45.12	-3.07*

Values are presented as mean ± standard deviation. *p<0.05, 6MWT: 6-minute walk test

elbow circumferences and 8.16% and 4.15% at a circumference of 10 cm below and above the elbow, respectively. Strengths were increased in the muscles of the surgical (flexor, 34.41%; extensor, 24.15%; external rotator, 35.73%; and internal rotator, 33.80%) and non-surgical (flexor, 16.04%; extensor, 16.39%; external rotator, 20.30%; and internal rotator, 23.56%) sides. SPADI scores decreased by 45.13%, 37.32 %, and 40.00% for pain, disability, and total scores, respectively. Furthermore, the 6 MWT score increased by 12.07%.

Ⅳ. Discussion

This study supports the effects of music-based rhythmic exercise program of upper and lower extremities on lymphedema, muscle strength, and physical function in post-mastectomy women.

Inactivity is one of breast cancer survivors' most challenging issues in the recovery of body function and is closely related to decreased muscle strength and aerobic capacity.[2,3] In this study, the intervention included two components: rhythmic exercise and treadmill walking training. Rhythmic exercises are mu-

sic-based exercises. music is used as a factor to induce interest and active participation during rehabilitation of patients with reduced exercise motivation, and treadmill exercise is a device that can increase the amount of whole-body exercise.[21] Listening to preferred music during training may be a better strategy to enhance exercise adherence in the long-term care of patients with breast cancer. In this study, treadmill walking was used as an aerobic exercise component. According to the American College of Sports Medicine exercise guidelines, at least 150 min of moderate- and high-intensity aerobic exercises per week and resistance exercise at least twice a week are recommended for patients with cancer.[22] In this study, treadmill training met this criterion. In addition, our intervention might benefit breast cancer survivors by saving time from the concurrent execution of the two intervention components.

Mastectomy may be a necessary option for treating breast cancer; however, scar tissue formation remains at the incision site, leading to severe chest pain and discomfort at rest and during movement.[23] Due to these problems, patients avoid using the affected arm and are less active in daily life, followed by poor posture, diminished fitness level, and functional decline. Furthermore, post-mastectomy lymphedema worsens arm pain and hinders efficient arm movement.[5] Therapeutic efforts are required to encourage loosening scar tissue and fascial tightness after mastectomy. This study intervention included rhythmic arm exercises with dumbbells. This study showed that the extent of lymph edema and the perceived pain level were significantly reduced after the intervention. Using a dumbbell, the extra load for strengthening shoulder muscles was individualized by examining the repetition maximum in each participant. Repeated arm motions may help release tightened tissue at the incision site after surgery. Rhythmic exercises with dumbbells aim to promote muscle strength of the affected arm. Since muscle strength is an important factor in shoulder function, increased shoulder muscle strength improves the SPADI score, which evaluates the degree of shoulder pain and dysfunction. Recent studies support these findings.[24,25,26,27]

After mastectomy, a less moving rib cage causes insufficient chest expansion during breathing, contributing to decreased cardiorespiratory function and aerobic capacity. In addition, deconditioning due to a lack of activity has been considered one factor that increases cancer mortality and recurrence. Therefore, regular aerobic exercise is recommended.[21] In clinical practice, treadmill walking training is commonly used to promote aerobic fitness in patients with functional impairments. As found in this study, the 6 MWT score, implying walking endurance, significantly improved after the intervention. An improved aerobic capacity has positive effects on muscle strength and function.[28] Listening to preferable music during training can be a better way to encourage exercise interest by matching arm and leg motions to the rhythm and tempo of the music to enable training effects.[13]

Treadmill exercise and dumbbell exercise applied in this study have been suggested in several studies as a treatment strategy for improving physical activity and functional movement of patients who need continuous management, such as breast cancer patients.[25,29] In this study, to improve functional movement, regular leg movements were performed using treadmill equipment, and exercises were actively performed to improve the stability of the shoulder joint as suggested in the guidelines by holding the dumbbells.[22] To breast cancer patients who have difficulty performing functional movements due to postoperative pain or excessive protection, rhythmic exercise using music and providing a regular environment using a treadmill made it possible to efficiently apply intervention. Through the results of this study, there is significance as a prior study that has shown that music-based rhythmic exercise program can be used as one of the exercise methods for improving physical problems in breast cancer patients.

This study has several limitations that can be addressed in future research. First, the sample size was small; therefore, it is difficult to generalize the findings to other groups. Second, no control group was included in this study. This indicates that this study might not have supported the intervention effects. Third, given that this study did not allow any fol-

low-up after an 8-week intervention period, the findings cannot be recognized as the long-term effects of the intervention. Finally, because the intervention in this study was based on outpatient rehabilitation services, it was impossible to completely control the participants' behavior during the study process. Large-scale studies with robust designs are needed to confirm our results.

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