NORDIC WALKING EXERCISES VERSUS RESISTIVE EXERCISES ON UPPER EXTREMITY STRENGTHAND VOLUME OF LYMPHOEDEMA POSTMASTECTOMY

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Conflict of Interest Statement

The authors whose names are listed immediately below certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Abstract

Background and Objective: Postoperative lymphedema post mastectomy is a secondary lymphedema, that alters lymph drainage of the breast, thoracic quadrants, and upper limbs. Its signs and symptoms include increased weight of the limb; paresthesia of the hand; stiffness of fingers; reduced range of motion and muscle weakness of upper so the aim of this study was to compare the effect of Nordic walking and muscle strength of upper limb post mastectomy. **Materials and Methods:**forty female patients 6 months post mastectomy, their ages between 45 to 60 years old, were defined as havingupper limb lymphedema and muscle weakness.The study was conducted from February 2016 to January 2018 .The

subjects recruited and underwent physical exam at surgery clinic in National Cancer Institute. The patients were randomly divided into two groups (A, B). Each group consisted of 20 patients. Group (A) received Nordic walking and traditional physical therapy for 8 weeks/ 2 sessions per week , group (B) received resistance exercise and traditional physical therapy for 8 weeks / 5 sessions per week, all patients were assessed pre and post treatment for these variables: Lymphedema measurements size and volume and Peak torque of shoulder extensors and flexors. **Results:** Statistical analysis revealed that there was a significant improvement in both groups in lymphedema measurement and peak torque of shoulder extensors and flexors pre and post values but group (B) which was resistance exercises had a superior effect on peak toque of shoulder extensors and flexors. There was no significant differencebetween both groups in lymphedema size. **Conclusion:** group (B) had a superior effect in muscle strength than Group (A) and no significant difference in lymphedema measurements between both groups.

Key words: Nordic walking, resistance exercises, lymphedema, upper limb muscle weakness.

Significant statement: This study confirmed that resistive exercises are more effective in treatment upper limb lymphedema and muscle strength. The study providing physiotherapist with the effective techniques used for treatment of lymphedema and muscle weakness in breast cancer patients.

INTRODUCTION

Every breast cancer operation, both conservative and radical, linked with axillary lymph node dissection results in certain restrictions in the mobility range of a shoulder joint, hindering, in the first phase, even simple everyday activities [1].

The shoulder on the treated side is elevated with the arm kept close to the trunk and consequently the distribution of muscle strength is disproportionate while shoulder joint muscles weaken [2].

Since the shoulder girdle, upper extremity and trunk are involved to a large extent in this activity an increase in the range of motion and muscle endurance is

expected as well as initiation of the muscular and vascular pump thus facilitating the transport of lymph from sites endangered or affected by lymphedema[3]**.**

In lymphedema patients, the amount of lymphatic drainage in muscle is always more than that in the subcutaneous tissue, and the mass of muscles is important for the occurrence of lymphedema. Therefore, the strength and tension of muscles can be increased by active resistance exercise, an effective treatment for reducing the volume of edema, especially in body parts with more muscle mass, such as the proximal part of the upper limbs**[4].**

The unused muscles slowly atrophy. Participation by women in rehabilitation following breast cancer treatment can reduce the negative effects on shoulder joint mobility range shortly after a surgical procedure. Muscle weakness lasts considerably longer, however, and requires a longer period of physiotherapy. Patients who actively exert physical effort are better motivated and show greater persistence in treatment[5]**.**Various forms of exercise have thus been prescribed for women following breast cancer treatment. These exercises aim at strengthening the muscles of the upper extremity and shoulder girdle on the treated side, improving general physical fitness and efficiency, preventing lymphoedema, correcting faulty posture and activating the immune system[6]**.**

The potential benefits of progressive resistancetraining soon after surgery has not been investigated even though many women report shoulder weakness [7]**.**

It is common believed that vigorous arm exercises will induce lymphedema although evidence from other studies challenge this belief to date, no studies have investigated the use of resistance training early after surgery, although this may be the stage at which exercises have the greatest effect in preventing lymphedema and muscle weakness**[8].**

MATERIALS and METHODS

Study design:

Pre test – Post test experimental study.

***Participants*:**Forty female patients after modified radical mastectomytheir ages were between 45 to 60 years old. Subjects were defined as having upper limb muscle weakness and lymphedema.Subjects were randomly assigned into 2 groups each group consisted of 20 patients. Subjects were randomly assigned into 2 groups using the simple randomization in selection.The first group was the group (A) who recieved Nordic walking exercises, the second group was the group B who received resistance exercises. The period of the study was 8 weeks for both groups, 2 sessions per week for group A and 5 sessions per week for group B.

I. Measurement procedures:

All subjects in this study were subjected to the following:

Full history taking and complete clinical examination:

For date of breast surgery and symptoms of upper limb muscle weakness and lymphedema.

1. Biodex isokinetic dynamometer objective tool for assessment of muscle strength pre and post treatment.

   Procedure of isokinetic measurement

   The respondent asked to full flex and extend shoulder joint throughout full range of motion to measure peak torque of shoulder felxors and extensors muscles and the movementperformed with 5 repetitions.[9]

Fig.1: peak torque shoulder flexion and extension

2. Tape measurement the method for measurement of lymphedema as the subject in sitting position with forearm pronated and the lymphedema was measured at 5 levels MCP,

   wrist,10cm below elbow,elbow,15cm above elbow.[10]

II. Treatment procedures :

Group (A) Nordic walking exercises

Nordic walking exercises in form of:

- Warm-up (10-min): involving exercise of the upper extremities with the use of poles
- Nordic walking (40-min) aimed at learning and improving walking technique with the use of special poles (load applied was 85% of maximum pulse value, calculated according to the formulapulse 220 – age = maximum function, with pulse monitored by use of Polar testers throughout the activity) as shown in Fig 2.

- Concluding part (10-min) involving the application of muscle stretching, respiratory and relaxation exercises [11].

Fig.2:Nordic walking exercise training

Group B: active resistive exercises

The patient performed resistive exercises by using of weights ranges between 0.5 to 1 kg as shown in Fig 3 in form of:[12]

- Seated row.
- Bench press.
- Latissimusdorsi pull-down.
- One arm bent-over row.
- Triceps extension
- Biceps curl.

Fig. 3: Active resistive exercises

Data Analysis:

- SPSS 19 version was used. (P- value, mean, standard deviation, t-value and mean difference)

RESULTS

The data concerning the effect of Nordic walking exercise and active resistive exercise on upper limb muscle weakness and lymphedema Data obtained from the two groups before initiation of treatment (Pre treatment) and after eight weeks of treatment (post treatment) regarding peak torque of shoulder flexors and extensors and lymphedema size and volume and were statistically analyzed and compared the level of significance for all tests was set as ($P \leq 0.05$).

The analysis of data revealed the following findings:

I-Peak torque of shoulder extensors and flexors:

Pre and post treatment mean values of shoulder extensors' and flexors' peak torque of group A:

- There was a significant increase in the shoulder extensors' peak torque post treatment compared with that pre treatment ($p = 0.002$) as shown in fig 4.

-There was a significant increase in the shoulder flexors' peak torque post treatment compared with that pre treatment ($p = 0.003$) as shown in fig4.

Pre and post treatment mean values of shoulder extensors' and flexors' peak torque of group B:

- There was a significant increase in the shoulder extensors' peak torque post treatment compared with that pre treatment ($p = 0.0001$) as shown in fig 5.
- There was a significant increase in the shoulder flexors' peak torque post treatment compared with that pre treatment ($p = 0.0001$)as shown in fig 5.

comparing peak torque of shoulder extensors and flexors group A and B:

- There was a significant increase in the shoulder extensors' peak torque of group B compared with that of group A post treatment ($p = 0.02$)as listed in table 1
- There was a significant increase in the shoulder flexors' peak torque of group B compared with that of group A post treatment ($p = 0.002$) as listed in table 1.

II . Lymphedema size:

Comparing lymphedema size between group A and B:

- At MCP level there was no significant difference in the lymphedema size group A and B post treatment ($p = 0.35$) as listed in table 2.
- At wrist level there was no significant difference in the lymphedema size group A and B post treatment ($p = 0.63$) as listed in table 2.

- At 10cm below elbow there wasno significant difference in the lymphedema size group A and B post treatment (p = 0.26) as listed in table 2.
- At elbow there was no significant difference in the lymphedema size group A and B post treatment (p = 0.69) aslistedin table 2.
- At 15cm above elbow there wasno significant difference in the lymphedema size group A and B post treatment (p = 0.44) as listed in table 2.

III. Lymphedema volume:

Comparing lymphedema volume between group A and B:

There was no significant difference in the lymphedema volume of upper limb between group A and B post treatment (p = 0.25).as listed in table 3.

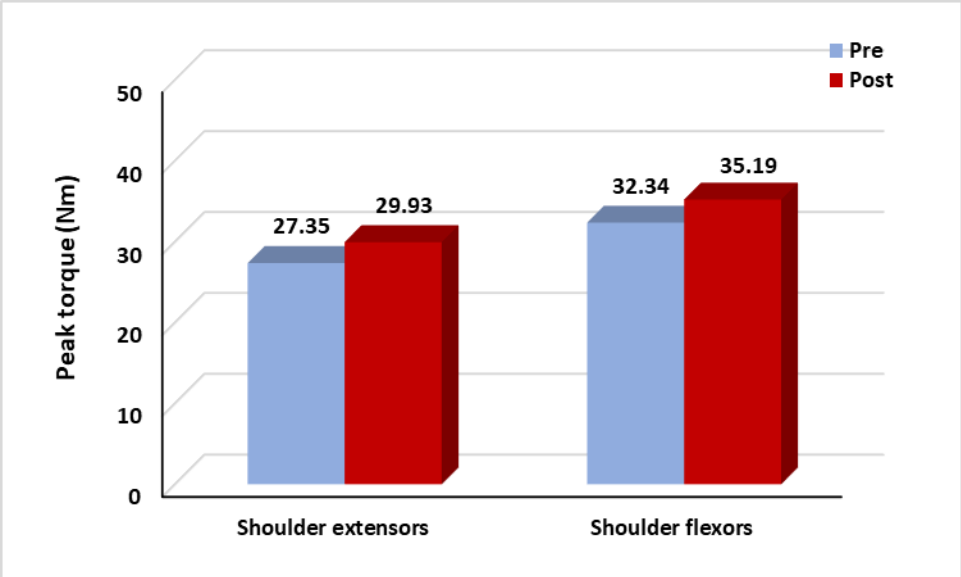

Fig.4:Pre and Post treatment mean values of shoulder extensors' and flexors' peak torque of group A.

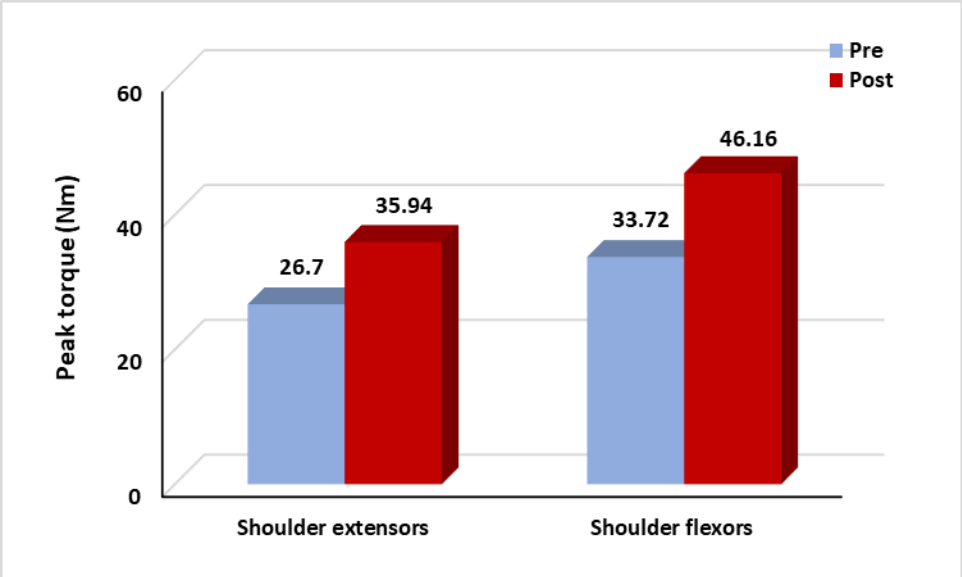

Fig.5:Pre and Post treatment mean valuesof shoulder extensors' and flexors' peak torque of group B.

Table 1. Comparison of post treatment mean values of shoulder extensors' and flexors' peak torque between group A and B:

Peak torque (Nm)	Group A	Group B	MD	t- value	p-value	Sig
	$\bar{X}$ ±SD	$\bar{X}$ ±SD				
Shoulder extensors	29.93 ± 5.31	35.94 ± 5.22	-6.01	-2.55	0.02	**S**
Shoulder flexors	35.19 ± 4.16	46.16 ± 8.54	-10.97	-3.64	0.002	**S**

$\bar{X}$: Mean, MD: Mean difference ,p value: Probability value, SD: Standard deviation t value: Unpaired t value, S: Significant

Table2.Comparison of post treatment mean values of lymphedema size between group A and B:

Lymphedema size (cm)	Group A	Group B	MD	t- value	p-value	Sig
	$\bar{X}$ ±SD	$\bar{X}$ ±SD				
MCP	21.3 ± 2.26	20.3 ± 2.45	1	0.94	0.35	**NS**
Wrist	22.3 ± 2.45	21.8 ± 2.2	0.5	0.٤٨	0.63	**NS**
Below elbow10 cm	30.7 ± 4.85	28 ± 5.53	2.7	1.15	0.26	**NS**
Elbow	33.5 ± 3.68	32.8 ± 4.15	0.7	0.39	0.69	**NS**
Above elbow15 cm	37.3 ± 3.74	35.9 ± 4.25	1.4	0.78	0.44	**NS**

$\bar{X}$: Mean, MD: Mean difference, p value: Probability value ,SD: Standard deviation t value: Unpaired t value, NS: Non significant

Table3. Comparison of post treatment mean values of lymphedema volume between group A and B:

	Group A	Group B	MD	t-value	p-value	Sig
	$\bar{X}$ ±SD	$\bar{X}$ ±SD				
Lymphedema volume (ml)	3738.62 ± 785.64	3366.49 ± 633.35	3.72.13	1.16	0.25	**NS**

$\bar{x}$: Mean. MD: Mean difference, p value: Probability value
t value: Unpaired t value , SD: Standard deviation

DISCUSSION

Regarding the effects of Nordic walking exercise in group A:

According to peak torque of shoulder muscles extensors and flexors pre and post treatment in group A

There was a significant increase in the shoulder extensors' peak torque post treatment compared with that pre treatment ($p = 0.002$).

There was a significant increase in the shoulder flexors' peak torque post treatment compared with that pre treatment ($p = 0.003$).

In related studies sprod et al., 2005[13] which examined the effect of Nordic Walking in form of intervention of 20 minutes per session for 8 weeks in breast cancer patients as it concentrated on the muscles of the upper extremities and shoulder which increased shoulder range of motion and decreased functional limitations in daily activities and that reflect the NW on muscle strength of upper limb.

Study showed similarity with Reigle and Wonders, 2009[14] asin their study the patients performed Nordic walking for 8 weeks in breast cancer patients and the program caused changes in muscle function in form of improvement in the strength of the muscles active during the pushing motion, consisting of shoulder flexion and extension for the whole upper extremity.

Study agreed with (Ripatti, 2002[15]; Gullstrand and Svedenhag, 2003[16]; Figard-Fabre et al., 2010[17]) as they found that intervention programs based on the regular practice of NW (between 3 and 4 times a week for several months) led to

improvements in muscle strength of the upper limbs up to 40% and reductions in neck and shoulder pain in breast cancer patients.

According to volume of lymphedema pre and post treatment in group A

There was a significant decrease At MCP level in the lymphedema size post treatment compared with that pre treatment (p = 0.04, at wrist level There was a significant decrease in the lymphedema size post treatment compared with that pre treatment (p = 0.03), Below elbow 10cm There was a significant decrease in the lymphedema size elbow post treatment compared with that pre treatment (p = 0.0001), at elbow level There was a significant decrease in the lymphedema size post treatment compared with that pre treatment (p = 0.01) and above elbow 15cm There was a significant decrease in the lymphedema size at 10 cm above elbow post treatment compared with that pre treatment (p = 0.01).

There was a significant decrease in the lymphedema volume of upper limb post treatment compared with that pre treatment (p = 0.0001).

The study agreed withChurch,2002[18] as their study was to investigate the effects of intensive pole walking on arm lymphedema in women treated for breast cancer. Measurements of arm lymphedema indicated a significant reduction in total arm volume of the lymphedema arm (p = 0.001), in lymphedema absolute volume (p = 0.014) and lymphedema relative volume (p = 0.015).

Results showed similarity withMustian et al.,2008[19]as in their study the application of Nordic walking as a method of arm lymphoedema reduction, 26 women with secondary unilateral upper extremity lymphedema were engaged in walking along a distance of 4 km for 60-min, according to findings Nordic walking improved the function of the upper extremity muscles on the side treated. Moreover, Nordic walking led to improvement of lymphoedema in women

following mastectomy and did not intensified it and was a safe form of rehabilitation for this group of patients.

Agreement also with Johansson et al., 2005[20]as it showed that performance of pole walking for 30 to 60 min, three times per week could be performed without increasing the arm lymphedema in breast cancer-treated women and also reduced lymphedema, tightness as well as improved fitness.

Also study agreed with Andrea et al., 2016[21]as 16 of breast cancer survivors were recruited and randomly assigned to 1 of 2 different training groups. They performed 10 lessons on Nordic walking technique plus the Isa method significantly reduced both extracellular body water and the extracellular-to-total body water ratio and also the circumference of the upper limb.

Regarding the effects of resistive exercises in (B) group:

According to peak torque of shoulder muscles extensors and flexors pre and post treatment in group B

There was a significant increase in the shoulder extensors' peak torque post treatment compared with that pre treatment ($p = 0.0001$). There was a significant increase in the shoulder flexors' peak torque post treatment compared with that pre treatment ($p = 0.0001$).

The result of this study showed agreement with Kolden et al., 2002[22]as 80 articipants engaged in a course of structured format in form of aerobic fitness, strength, and flexibility three times per week for 16 weeks. Assessments of fitness/vigor and quality of life were conducted prior to, during, and upon completion of the program. Results demonstrated that program was safe, well-tolerated and there was increasing in strength and flexibility.

Also showed similarity with Adamsen et al., 2003[23]as 23 cancer patients participated in groups of seven to nine patients for 9 h weekly for 6 weeks examined the effects of an exercise program, the supervised program included

high- and low-intensity activities (physical exercise, relaxation, massage, and body-awareness training) . Repetition maximum and maximal oxygen uptake were compared prior to and after completion of the program. The program was safe and well tolerated. The completion rate was 85.2%. Highly significant increases in physical capacity and an improved level of physical activity were achieved.

Also showed agreement with Rorth and Andersen, 2005[24]as the patients engaged in a program includes high and low intensity activities, repetition maximum strength (RM) were compared prior to and after completion of the program carried out in groups of 7–9 patients for 6 weeks and there were great improvement in muscular strength, physical fitness and physical activity level, reduced treatment related side-effects and improve their quality of life by participating in a multidimensional exercise program.

According to size and volume of lymphedema in group B

There was a significant decrease in the lymphedema size at MCP level post treatment compared with that pre treatment (p = 0.0001), at wrist level There was a significant decrease in the lymphedema size at wrist level post treatment compared with that pre treatment (p = 0.009), below elbow 10 cm level There was a significant decrease in the lymphedema size at 10 cm below elbow post treatment compared with that pre treatment (p = 0.0001), at elbow level There was a significant decrease in the lymphedema size at elbow level post treatment compared with that pre treatment (p = 0.0001) and above elbow 15cm level There was a significant decrease in the lymphedema size at 10 cm above elbow post treatment compared with that pre treatment (p = 0.0001).

There was a significant decrease in the lymphedema volume of upper limb post treatment compared with that pre treatment (p = 0.0001).

Results agreed with Harris and Niesen-Vertommen, 2000[25] as 20 women who had received axillary dissection and who were competing in the vigorous, upper body sport of Dragon Boat racing obtained serial as armcircumference measurements showed no increasing in lymphedema and that proved that women after breast cancer treatment can safely engage in strenuous upper extremity exercises.

Study also agreed with Turner et al., 2004[26]as their project assessed the effect of a mixed-type, moderate-intensity exercise programme post breast cancer treatment, and the impact on presence of lymphoedema, fitness, body composition, fatigue, mood and quality of life as ten women completed the programme and measures of lympoedema by bio-electrical impedance and arm circumferences, in 6-week and 3-month follow-up and the participation in this program showed no increasing on the presence of lymphoedema.

Results also agreed with Lane et al., 2005[27], they measured lymphatic function during intermittent and moderate exercise in breast cancer patients with and without lymphedema byinjection an isotope into the hands of nondisabled women and determined that 5 minutes of exercises using an arm ergometer that there was enhancement of lymphatic clearance in the hand and that proved that exercise can improve lymphatic drainage.

Study disagreed withMutrie et al., 2007[28], as they found that high exercise intensity involving the upper limb is more effective than low exercise intensity in promoting lymphatic clearance in healthy women. In our study, the resistance training was with low weights and many repetitions (minimum of 15 repetitions). However, similar results were found in the study by Courneya et al., 2007[29], in which heavier weights and fewer repetitions were used.

Results also agreed with the studies of Ahmed et al., 2009[30] they performed a randomized, controlled trial of twice-weekly progressive weight lifting involving

141 breast-cancer survivors with stable lymphedema of the arm. The outcome was the change in arm and hand swelling at 1 year, as measured through displaced water volume of the affected and unaffected limbs as compared with the control group, the weight-lifting group had greater improvements in self-reported severity of lymphedema symptoms

Results showed similarity withKwan et al., 2011[31], as publications which retrieved from 11 major medical indices for articles published from 2004 to 2010 using search terms for exercise and lymphedema; articles were reviewed by clinical lymphedema experts, studies were identified addressing resistance exercise, aerobic, resistance exercise, and other exercise modalities. Studies proved that slowly progressive exercise of varying modalities is not associated with the development or exacerbation of breast cancer-related lymphedema and can be safely pursued with proper supervision. Combined aerobic and resistance exercise appear safe.

Also study agreed with Paramanandam et al., 2014[32] as they examined the effect of progressive weight training exercise on lymphedema, the primary outcomes were severity (volume difference) and incidence of arm lymphoedema. Secondary outcomes included muscle strength of the upper and lower limbs soweight training appears to be safe and beneficial in improving limb strength and physical components of quality of life in women with or at risk of lymphoedema

Regarding the effect of Nordic walking and resistance exercises between group A and B on muscle strength, the results showed improvement in group B more than group A in improvement in muscle strength which supported by (Ripatti, 2002[15];Kolden et al., 2002[22]; Gullstrand and Svedenhag, 2003[16]; Adamsen et al., 2003[23]; sprod et al., 2005[13];Rorth and Andersen, 2005[24]; Reigle and Wonders, 2009[14] and Figard-Fabre et al., 2010[17]**)** They found that Nordic walking (NW) could improve muscle strength through:

- Nordic walking showed improvements in dynamic balance, but with diverse results. Differently from the static.
- Nordic walking is characterized by an active involvement of lower and upper limbs, guaranteeing potential benefits for both upper- and lower-body.
- Nordic walking has been estimated as producing up to a 46% increase in energy consumption, compared to walking without poles.
- Nordic walking significantly improved muscular endurance of the upper body.

Also showed that resistance exercises improved muscle strength through:

- The resistance must be sufficient to increase the intra-muscular tension to the maximum without interfering with the ability of the muscle to do coordinated movements.
- Increasing lean muscle mass, muscle strength, and endurance are also expected to have significantly positive effects on physical functional ability and result in an elevated maximal work capacity.
- Regaining and improving physical function, aerobic capacity, strength and flexibility.
- Improvement in bone mineral density.
- Significant improvements in immune parameters, including natural killer cell cytotoxic activity.
- Prevention of side-effects from surgery as deviation of both side of body.

Regarding the effect of Nordic walking and resistance exercises between group A and B on upper limb lymphedema volume, the results showed improvement in group A and B with no significance difference between both groups and that supported by **(**Harris and Niesen-Vertommen, 2000[25]; Turner et al., 2004[26]; Lane et

al., 2005[27]; Courneya et al., 2007[29]; Mutrie et al., 2007[28]; Mustian et al.,2008[19]; Ahmed et al., 2009[30]; Johansson et al., 2005[20]; Kwan et al., 2011[31]; Paramanandam et al., 2014[32]; Andrea et al., 2016[21])as they found that Nordic walking could affect lymphedema as following:

- Dynamic muscular activity and exercise are important as management of lymphedema and preferred to static exercise such as gripping. Since pole walking is partly about gripping, the advice, ‘‘Do not grip the pole too firmly’’ was repeated while walking, trying to minimize the static exercise.
- Nordic walking can cause muscle strength which improve muscle pump and enhance lymphatic drainage.
- Nordic walking can improve cardiovascular system and improve circulation which enhance lymphatic clearance.

Also they found that resistance execersie could affect lymphedema volume as following:

- Use of a structured resistance training program could enhance lymph flow, improve protein resorption, and generally improve flexibility of soft tissues which reducing the secondary impact on venous and lymph obstruction.
- Regular resistance exercise is necessary to invoke lymphangiogenesis which could help to reduce the stress put on the lymphatic vasculature damaged by axillary lymph node dissection and radiation to the axilla so improve lymphatic drainage.
- Exercise also stimulates the skeletal muscle to pump venous and lymphatic fluid and also stimulate the contraction of the lymph vessels themselves because these vessels are innervated by the sympathetic nervous system. Regaining control over these internal contractions by resetting the

sympathetic drive to these vessels through upper-body exercise so can assist in the long-term treatment for lymphedema.

Finally, the results of this study proved that both Nordic walking exercises and resistive exercises achieved great improvement in both muscle strength and reduction size and volume of lymphedema.

There was significant improvement in muscle strength in group B more than group A in muscle strength but there was no significant difference in size and volume of lymphedema between both groups.

CONCLUSION

Resistive exercises are more effective than Nordic walking exercises in case of upper limb muscles strength post mastectomy.

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