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Neuromuscular Electrical Stimulation on Shoulder Dysfunction Post Mastectomy

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ABSTRACT

Background: Neuromuscular electrical stimulation (NMES) is a therapy approach that has been utilised to speed the rehabilitation of individuals with neurological injury. NMES stimulation has been shown to be an effective adjunct in the enhancement of muscle recruitment.

Objective: To investigate the effect NMES on shoulder dysfunction after mastectomy operation.

Patients and Methods: Sixty-eight female patients with age ranged from 40-55 years, with shoulder dysfunction after mastectomy were participated in this study. They were assigned randomly and equally in two groups. Shoulder range of motion "ROM" was measured pre, after 3 weeks (post 1) and after 6 weeks (post 2) by electronic goniometer. Shoulder dysfunction was assessed by disability of Arm, Shoulder and Hand (DASH) scale; **Group A** received NMES and exercise program (stretching, strengthening and active ROM exercises) 3 sessions per week for 6 weeks. **Group B** received exercise program.

Results: There was a significant difference in shoulder ROM and dysfunction between pre, post1, and post 2 in group A as P value was (0.001). but there was no significant difference in pre, post1 and post 2 measurements in group B as P value was <0.05. **Conclusion:** Neuromuscular electrical stimulation is an effective method for treatment of shoulder dysfunction post mastectomy.

Keywords: Shoulder dysfunction - NMES - Exercise program.

INTRODUCTION

Due to the prevalence of persistent post-mastectomy pain (PPMP) and its potential severity, research on the condition has increased, underscoring the significance of improving the quality of life (QOL) for post-surgical breast cancer patients. Breast cancer is the most common cancer among women. The sensation of dull burning and aching in the chest, axilla, and ipsilateral upper limb after a mastectomy has been identified as a significant post-surgical consequence. This pain is ascribed to injury caused to the intercostal-brachial nerve during surgical dissection [(1)].

6 months after surgery, up to 50% of patients experience chronic pain. Compared to patients without persistent breast pain or women without a history of cancer, those with persistent breast pain exhibit significantly higher levels of depressive symptoms, increased anxiety, and increased fear of pain. Unmanaged pain following surgery is a significant risk factor for chronic pain syndrome [(2)].

It is believed that between 25% and 60% of breast cancer survivors endure post-surgical chronic pain, which is linked to a worse QOL and motor dysfunction, despite an 83% survival rate. A generalised hypersensitivity of the somatosensory system, which is described as an amplification of the neural signal at the level of the central nervous system, is one of the characteristics that some patients with chronic pain exhibit, which may indicate central pain sensitization [(3)].

In individuals who have had mastectomy surgery, one of the most frequent musculoskeletal complications is shoulder dysfunction because of pain, connective tissue fibrosis, limited ROM, and restricted shoulder mobility following the procedure. Although decreased ROM and function following breast cancer surgery has long been acknowledged as an issue, few studies have compared these findings with preoperative measures to ascertain the occurrence of these changes in this clinical group. Twelve months following an axillary dissection for breast cancer, twelve percent of the women did not restore complete ROM in their shoulders based on preoperative comparisons for flexion, abduction, internal rotation, and external rotation motions. Within the first two years following surgery, rates of shoulder mobility loss have been reported to be 17% and 32%.

Despite the fact that less invasive surgical techniques are being used with adjuvant treatments, it is still suggested that impaired shoulder ROM postoperatively may remain a potential problem for some women undergoing breast cancer treatment despite this current surgical practice and the avoidance of radiotherapy to the axillary region when possible [(4)].

Using an electrical stimulator to send electrical impulses through the skin and into the muscles and nerves is known as NMES. NMES increases the shoulder muscle fibers recruitment, promoting their physiological contraction and prevent the post incisional atrophy, therefor help maintain shoulder muscles strength and prevent incision-induced atrophy. NMES can include Transcutaneous Electrical Nerve Stimulation (TENS) that help decrease incisional site pain and improve overall shoulder function [(5,6)].

This study aimed to investigate the effect NMES on shoulder dysfunction after mastectomy operation.

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PATIENTS AND METHODS

Sixty-eight patients who had shoulder pain and dysfunction post-mastectomy operation were include in this study, their ages ranged from 40 to 55 years. The participants were selected from government hospitals (General and Insurance Hospitals). The purpose, rationale, and benefits of this study were explained for each subject. After that, they signed a consent form according to Helsinki protocol and randomly distributed into 2 equal groups (group A, group B).

Inclusion criteria:

1. Age ranged between 40 – 55 years.
2. All patients who had shoulder pain after breast cancer surgical removal.
3. Modified radical type of mastectomy surgical approach.
4. All patients passed two months post-operation [7].

Exclusion criteria:

1. Age less than 40 years or more than 55 years.
2. Patients who had co-morbidities such as (diabetes mellites, rheumatoid arthritis, hypertension, cardiac, renal patients etc.).
3. Cognitive problems or hearing loss.
4. Pre-existing joint disorder before mastectomy.
5. Previous surgery on the chest wall.
6. Bilateral mastectomy.
7. Patients who received chemotherapy.
8. Patients with lymphedema [8].

MEASUREMENT PROCEDURES

1- Range of motion (ROM):

Using a digital goniometer, the examiner assessed the passive ROMs (pROMs) and active ROMs (aROMs) for flexion, abduction, and external rotation at a neutral posture. After each patient took a stool seat, the ROM was assessed in all directions. Flexion and abduction were permitted with scapular rotation. With the forearm in a neutral supination-pronation position, the elbow flexed at a straight angle, and the shoulder adducted, external rotation was measured in a neutral posture [9]. Patients were instructed to move their arms as far as possible for the aROMs measurement, but the examiner moved each subject's arm until it was limited mechanically or by discomfort for the pROMs measurement [10].

2- Shoulder dysfunction:

By The Disabilities of the Arm, Shoulder and Hand (DASH) Scale: The primary component of the DASH is a 30-item disability/symptom scale regarding the patient's health state during the prior week. The items inquire about the difficulty in performing various physical activities as a result of the arm, shoulder, or hand problem (21 items), the severity of each of the symptoms of pain, activity-related pain, tingling, weakness, and stiffness (5 items), and the problem's impact on social activities, work, sleep, and self-image (4 items) [11].

Each item includes five answer possibilities. The DASH score represents the disability/symptom scale. The DASH is assessed in two parts: the disability/symptom questions (30 items, rated 1–5) and the optional high-performance sport/music or job segment (4 items, rated 1-5). A score may be determined only once at least 27 of the 30 items have been completed [12]. DASH Disability/Symptom Score = [(sum of n replies) - 1] x 25, where n is the number of completed responses. A DASH score cannot be computed if more than three elements are missing [13].

TREATMENT PROCEDURES

Both groups were given a general shoulder training program (strengthening, stretching, and ROM exercises) three times per week for six weeks.

Exercises program:

Exercise treatment improves shoulder musculoskeletal risk factors in patients with head and neck cancer and reduces the occurrence and management of shoulder discomfort [13]. A verbal and visual demonstration of the exercise procedure was given to each subject by the therapist during every session of treatment. The exercises session consisted of: 1- Prolonged stretching exercises to anterior shoulder, chest muscles and fascia that were predisposed to post-surgical shortening and contracture; mainly pectoral fold, anterior and inferior shoulder capsules (15 minutes). 2- Strengthening exercises to shoulder flexors, abductor and external rotators that are responsible for shoulder elevation (15 minutes). 3- Active ROM exercises into direction of flexion, abduction and external rotation (15 minutes) [14].

Neuromuscular electrical stimulation group (NMES):

Group A received NMES, exercise program (stretching, strengthening and active ROM exercise) and routine medical treatment. The patients had three sessions each week for six weeks, time of the session was 45 minutes for NMES and 45 minutes for exercise program [15]. NMES was done by a portable, two-channel neuromuscular stimulator. NMES (Surged Faradic Current) 35 - 70 HZ, pulse width 200μs.TENS 100 HZ, pulse width 100μs. The surface electrode was placed close to the posterior region of the deltoid muscle and the supraspinatus motor point. The posterior deltoid and supraspinatus muscles were chosen as the treatment's primary targets because they are essential for preserving proper shoulder alignment and stabilising the shoulder joint [16]. It has been demonstrated that using therapeutic electrical stimulation to the posterior deltoid and supraspinatus muscles can enhance muscular power, lessen shoulder discomfort and weakness, and enable shoulder [17]. The posterior deltoid muscle belly electrode location was two finger widths inferior to the posterior acromion process edge [18].

Exercises group

The second group (Group B) got typical physical therapy treatments. Prolonged stretching exercises to anterior shoulder, chest muscles and fascia that were predisposed to post-surgical shortening and contracture mainly pectoral fold, anterior and inferior shoulder capsules (15 minutes). 2- Strengthening exercises to shoulder flexors, abductor and external rotators that are responsible for shoulder [19] elevation (15 minutes). 3- Active ROM exercises into direction of flexion, abduction and external rotation (15 minutes) [20].

Outcome measures:

Each patient had a complete history taken, and they also had neurological, musculoskeletal, and systemic physical tests. Patients were questioned in-depth about operations. Age, dysfunction, and shoulder ROM were recorded for each patient. Data on shoulder ROM and disability of the arm, shoulder, and hand (DASH-physical function), collected from the two groups prior to treatment, three weeks later (post I), and six weeks later (post II), were compared and statistically examined.

Ethical approval:

The Ethics Committee of the Faculty of Physical Therapy at Cairo University approved the study (Ethics Protocol reference No.: REC/012/004072). Following a detailed description of the study's aims, all participants completed an informed consent form. The Helsinki Declaration was observed throughout the study's duration.

Statistical analysis

The SPSS V. 25.0 for Windows was used to run all statistical analyses. Data were presented as mean±standard deviation (SD). Unpaired t-test was used to compare means of the 2 groups. While ANOVA with repeated measurements was used to compare means of the same parameter at different times, within the same group. Every statistical test has a significance threshold of $p < 0.05$.

RESULTS

Subjects' demographic data:

As observed in table (1) and figure (1), there was no significant difference in age between the 2 studied groups.

Table (1) Descriptive statistics and comparison of age between group A and B.

Age (years)	**Group A**	**Group B**
Mean±**SD**	47.97 ± 5.11	47.62 ± 5.07
Maximum	55	55
Minimum	40	40
Mean difference	0.35	
t-value	0.28	
p-value	0.77	
Significance	**NS**	

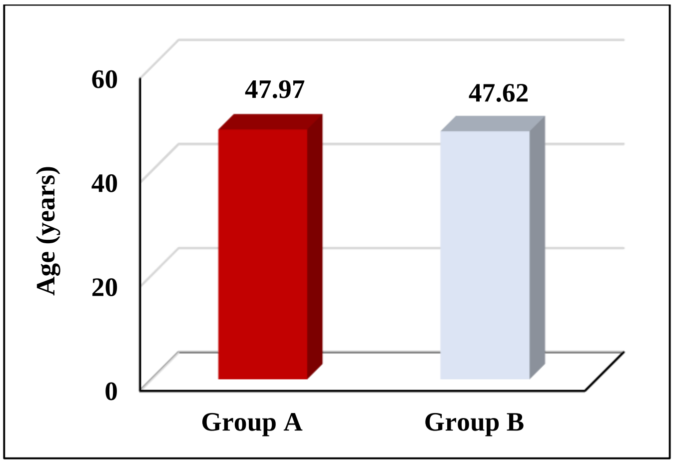

Figure (1) Comparison of mean age between group A and B.

Treatment's impact on ROM for external rotation, flexion, abduction, and DASH:

Comparing within group

When comparing the DASH scores of both groups at post II to pretreatment and post I, there was a significant drop, and when comparing post I to pretreatment, there was a significant decrease (Table 2 and figure 2).

ROM of flexion, abduction, and external rotation showed substantial increases in both groups at post II compared to pretreatment and post I, and at post I compared to pretreatment (Table 3 and figure 3).

In between group comparison

Prior to therapy, there was no discernible difference between the groups. At post I and post II, group A's DASH scores for physical function, symptoms, and severity were significantly lower than group B's (Table 2 and figures 2). At post I and post II, group A's ROM of flexion, abduction, and external rotation were significantly higher than group B's (Table 3 and figure 3).

Table (2): Mean DASH at pre-ttt, post I and post II of group A and B.

	Group A	Group B			
	mean ± SD	**mean ± SD**	**MD**	**t-value**	**p-value**
Physical function					
Pretreatment	73.65 ± 15.97	70.94 ± 15.61	2.71	0.71	**0.48**
Post I	42.06 ± 10.68 [a]	52.30 ± 12.71 [a]	-10.24	-3.59	**0.001**
Post II	33.07 ± 9.87 [a, b]	42.03 ± 11.35 [a, b]	-8.96	-3.47	**0.001**
	p = 0.001	***p = 0.001***			
Symptoms and severity					
Pretreatment	63.31 ± 16.51	65.38 ± 17.02	-2.07	-0.51	**0.61**
Post I	36.07 ± 10.72 [a]	45.78 ± 12.75 [a]	-9.71	-3.39	**0.001**
Post II	28.31 ± 9.59 [a, b]	37.19 ± 11.53 [a, b]	-8.88	-3.45	**0.001**
	p = 0.001	***p = 0.001***			

[a] significant difference with pretreatment; [b] significant difference with post I.

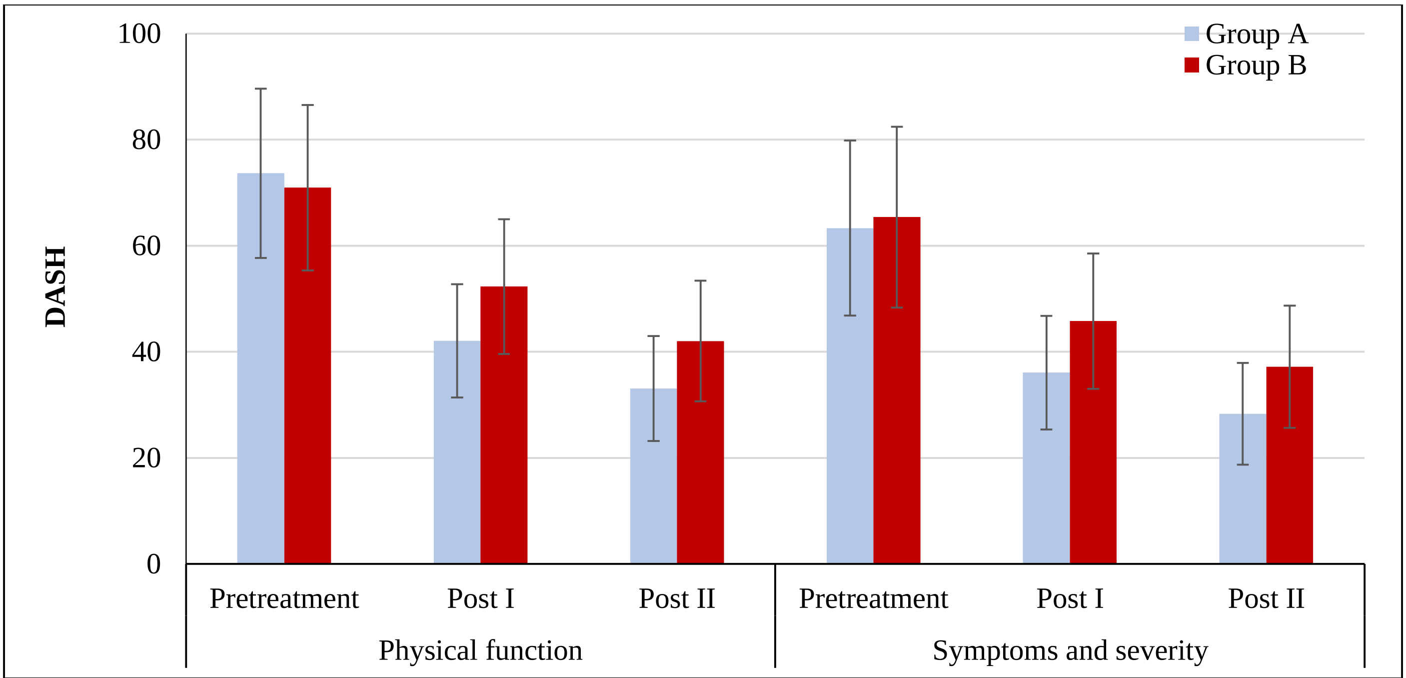

Figure (2) Mean DASH at pre-ttt, post I and post II of group A and B:

Table (3) Mean flexion, abduction and external rotation ROM at pre-ttt, post I and post II of group A and B:

ROM (degrees)	Group A	Group B			
	mean ± SD	**mean ± SD**	**MD**	**t-value**	**p-value**
Flexion					
Pretreatment	104.73 ± 7.77	103.55 ± 8.49	1.18	0.59	**0.55**
Post I	134.69 ± 8.51 [a]	124.37 ± 8.77 [a]	10.32	4.91	**0.001**
Post II	150.83 ± 8.62 [a, b]	135.73 ± 9.26 [a, b]	15.1	6.95	**0.001**
	p = 0.001	***p = 0.001***			
Abduction					
Pretreatment	82.63 ± 12.03	84.06 ± 11.28	-1.43	-0.50	**0.61**
Post I	104.54 ± 8.14 [a]	96.39 ± 7.63 [a]	8.15	4.25	**0.001**
Post II	115.83 ± 9.53 [a, b]	104.13 ± 9.21 [a, b]	11.7	5.14	**0.001**
	P = 0.001	***P = 0.001***			
External rotation					
Pretreatment	33.25 ± 5.57	32.95 ± 3.59	0.3	0.26	**0.79**
Post I	46.73 ± 6.70 [a]	40.08 ± 6.43 [a]	6.65	4.16	**0.001**
Post II	57.62 ± 4.92[a, b]	47.25 ± 3.50 [a, b]	10.37	10.01	**0.001**
	P = 0.001	***P = 0.001*** ***P = 0.001***			

[a] significant difference with pretreatment; [b] significant difference with post I.

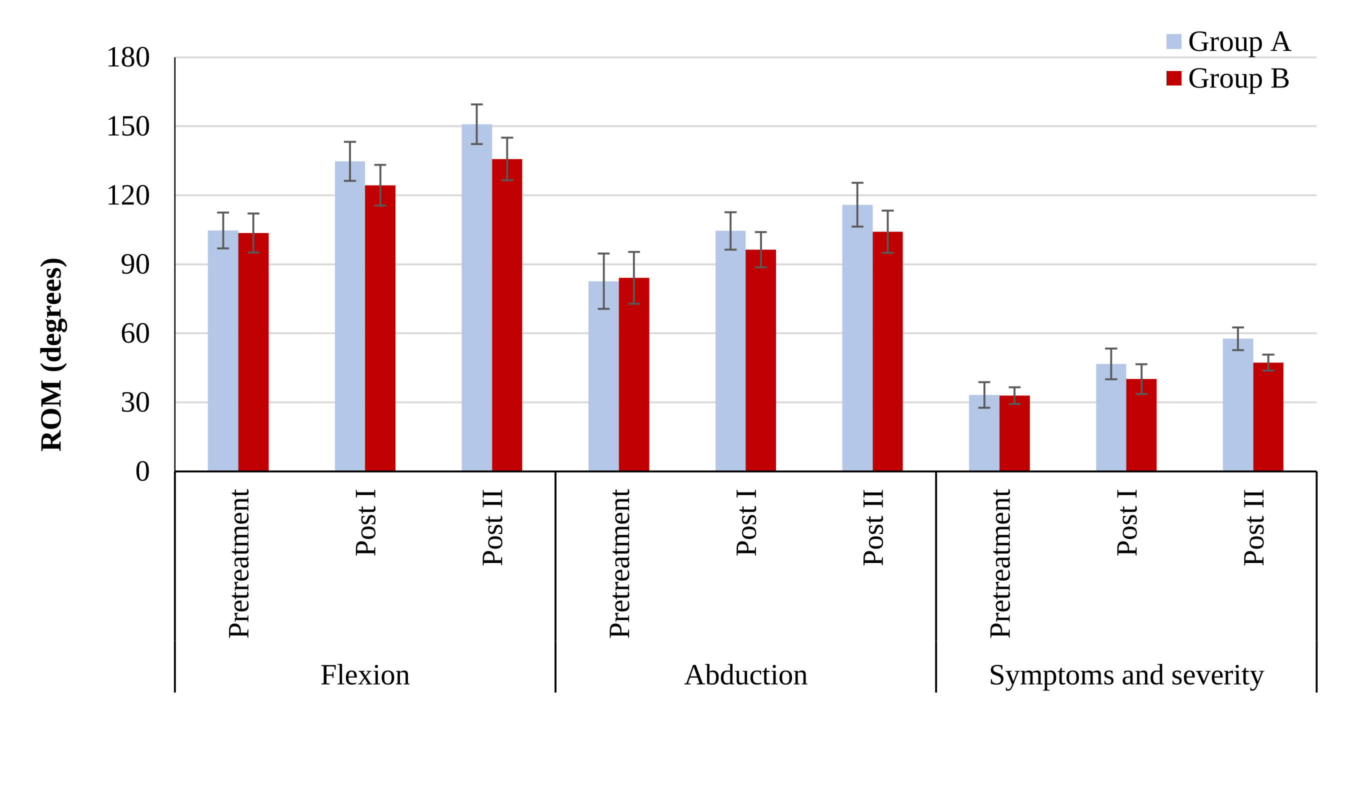

Figure (3) Mean flexion, abduction and external rotation ROM at pre-ttt, post I and post II of group A and B.

DISCUSSION

The current study was done to explore the impact of NMES on shoulder dysfunction following mastectomy procedures. There was less scientific evidence regarding the effect of NMES on shoulder dysfunction after mastectomy operations. Sixty-eight subjects participated in this study and were classified randomly into two equal groups; group A (experimental group) received (NMES and exercises program). Group B (control group) received exercises program (strengthening and stretching exercises).

The results of this study revealed that 6 weeks of shoulder NMES combined with stretching and strengthening exercises can improve overall shoulder dynamic movement, muscles strength, ROM and mobility. According to the data analysis in the current study, the results of NMES combined with strengthening and stretching exercises program revealed that there was an improvement after 6 weeks of treatment in the values of shoulder ROM (flexion, abduction and external rotation) and dysfunction (physical function and symptoms severity) with percentages of 44.02%, 40.18%, 73.29%, 55.10%, and 55.28% respectively.

The inter group analysis of our study has shown statistical significance in improving the shoulder dysfunction after mastectomy operations between the groups with more mean difference in NMES (intervention) group. This significant finding suggests that by applying NMES to shoulder joint post mastectomy there is associated improvement in the muscle strength, joint ROM, mobility, physical function and symptoms severity such as pain, tingling and heaviness. With improving the functional performance with good static and dynamic strength [21].

Conley *et al.* [22] performed a comprehensive review encompassing eight RCTs, in order to determine the impact of NMES on quadriceps strength following knee surgery, such as anterior cruciate ligament reconstruction (n = 5), total knee arthroplasty (n = 2), and meniscectomy (n = 1). They found, with grade B evidence, that NMES aided in the rehabilitation of quadriceps strength following knee surgery.

Another randomized-controlled pilot study conducted by **Ambrosini *et al.*** [23] assessed the improvement of upper extremity motor skills in patients with acute-subacute stroke, and secondly, the impact of the FES-cycling ergometry training on shoulder discomfort and subluxation. Their findings demonstrated that as compared to the normal rehabilitation program, shoulder discomfort decreased more in the FES-cycling group.

Sung *et al.* [24] conducted an investigation of the impact of intramuscular low frequency electrical stimulation on people with hemiplegia who experience shoulder discomfort. Two groups of twenty-five individuals with hemiplegic shoulder discomfort were formed. They used intramuscular electric stimulation for twenty minutes, three times a week, for a total of ten sessions, using a stainless-steel acupuncture needle implanted on the motor points of the middle deltoid muscle, supraspinatus, infraspinatus, and trapezius muscles for the experimental group.

Chlebowski *et al.* [25] used transcutaneous electrical nerve stimulation for twenty minutes on the control group. They assessed the shoulder joint passive ROM and VAS. The experimental group's VAS was reduced dramatically from 7.23±0.83 to 3.04±1.52, whereas the control group's VAS decreased little from 7.50±0.70 to 5.64±0.74. By comparing the experimental group to the control group, there was a substantial improvement ($p<0.05$) [25]. Abduction motion improved significantly in the experimental group, from 103.6±20.5 to 134.0±32.3, and external rotation improved from 60.0±19.6 to 68.6±19.7. The results demonstrated that both pain and ROM were improved by intramuscular low frequency electrical stimulation. Hemiplegic shoulder discomfort might be treated with this [26].

In a different investigation, **Lee *et al.*** [27] sought to ascertain the beneficial impact of NMES in traditional dysphagia therapy on patients' masseter muscle oral dysfunction following subacute stroke. Twenty patients each were randomly allocated to the study group and the control group. The beginning values and baseline attributes did not differ significantly between the two groups. Both groups' overall functional dysphagia scale (FDS) and pharyngeal phase FDS scores improved after two weeks of NMES. The research group also showed improvement in FDS during the oral period. Accordingly, they came to the conclusion that NMES for the masseter muscle had a therapeutic impact on patients' oral dysfunction following subacute stroke.

In a study by **Miller *et al.*** [28]**,** the glenohumeral kinematics of patients with a symptomatic full-thickness supraspinatus tear were compared before and after a 12-week exercise program. They discovered that, in a sample of five patients, exercise therapy was successful in improving the glenohumeral joint kinematics and patient-reported outcomes by increasing rotator cuff muscle strength and joint stability in patients with small full-thickness supraspinatus tears. The prognostic markers that indicate how a patient with a rotator cuff injury will respond to exercise treatment for ROM and disability reduction may be identified according to this study.

On the other hand, **Brudvig *et al.*** [29] conducted in treating patients with shoulder dysfunction research, comprising seven RCTs, that compared the advantages of mobilisation in addition to therapeutic exercise with therapeutic exercise alone. They came to the conclusion that, when treating shoulder dysfunction, joint mobilisation added to therapeutic activities is preferable to therapeutic exercises alone.

The lesser improvement in shoulder dysfunction among the subjects in the exercise group may be due to less analgesic effect of exercises than that of NMES or little muscle fibers recruitment during exercise program [30]**.**

CONCLUSION

NMES is an effective treatment method for shoulder dysfunction post mastectomy.

Contribution of the paper:

- NMES is an effective treatment modality for shoulder dysfunction post mastectomy operations.
- NMES can be used in management of impaired shoulder function post mastectomy operations.
- Further studies should be conducted to investigate combination of NMES and other exercise programs.

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