**International Journal of Environmental Sciences**
ISSN: 2229-7359
Vol. 11 No. 17s, 2025
https://www.theaspd.com/ijes.php

# Pilates Exercises Versus Proprioceptive Neuromuscular Facilitation Post Mastectomy: A Controlled Clinical Trial

**Ahmed Raafat Ahmed[1], Eman Mohamed Othman[1], Ashraf El-Sebaie Mohamed[2], Hesham Galal Mahran[1]**

[1]Department of Physical Therapy for Surgery, Faculty of Physical Therapy, Cairo University, Egypt.
[2]Department of Plastic Surgery, Faculty of Medicine, Cairo University, Egypt.

***Abstract***

***Background:*** *Mastectomy can lead to restricted shoulder range of motion, which can impact daily activities. Pilates exercises are a series of movements that aim to improve core strength, flexibility, and balance. Research indicates that Proprioceptive Neuromuscular Facilitation technique is effective in improving and maintaining Range of Motion, increasing muscular strength, power, and athletic performance, especially after exercise.* ***Objective:*** *This study aimed to compare the effects of Pilates and Proprioceptive Neuromuscular Facilitation (PNF) on shoulder ROM, pain and disability in women post modified radical mastectomy.* ***Methods:*** *60 female patients with modified radical mastectomy one month after surgery, aged between 40 and 65 years participated in the study. They were divided into three equal groups in number; group A received Pilates exercises and a traditional physical therapy program, group B received PNF exercises and a traditional physical therapy program, and group C received a traditional physical therapy program only. All treatments extend three times a week for twelve weeks. The range of motion was assessed using an electronic goniometer, and shoulder pain and disability were evaluated using a shoulder disability scale, both before beginning of treatment and after three months after treatment.* ***Results:*** *There were significant improvements in shoulder range of motion, and shoulder pain and disability index scores of groups A and B compared to group C (P <0.05).* ***Conclusions:*** *Both Pilates and Proprioceptive Neuromuscular Facilitation (PNF) exercises significantly improved shoulder function and reduced pain in post-mastectomy patients.*

***Keywords:*** *Mastectomy, Range of motion, Pain, Disability, Pilates Exercises, Proprioceptive Neuromuscular Facilitation.*

## INTRODUCTION:

Breast cancer is the most common cancer among women worldwide, with significant variations in incidence rates across different regions—Treatment options range from surgery, chemotherapy, and radiation therapy to hormone and targeted therapies. Complications of breast cancer include lymphedema, reduced mobility, chronic pain, and psychological distress, particularly after treatments like mastectomy. Early detection and comprehensive care remain essential in reducing mortality and enhancing recovery outcomes. [1]..

Mastectomy, a surgical procedure for breast cancer treatment, can lead to various complications that significantly impact a patient's physical and emotional well-being. One of the primary consequences is lymphedema, a condition characterized by swelling resulting from the accumulation of lymphatic fluid, often affecting the arm and chest. Additionally, restricted shoulder mobility and muscle weakness can hinder daily activities, reducing overall functionality. Beyond the physical effects, mastectomy patients frequently experience psychological distress, including anxiety and depression, as they navigate body image changes and the emotional toll of cancer recovery. The procedure also has direct systemic effects, with potential neuropathic pain due to nerve damage and seroma formation, where fluid accumulates under the surgical site. [1].

Physical therapy plays a crucial role in managing post-mastectomy complications by addressing joint stiffness and muscular atrophy, utilizing techniques to restore strength and function. Comprehensive care, including physiotherapy and psychological support, remains essential for optimizing the patient's quality of life following mastectomy. [14].

Two commonly used rehabilitation approaches for women after mastectomy are Pilates exercises and Proprioceptive Neuromuscular Facilitation (PNF). Pilates exercises are a form of exercise that focuses on strengthening the core muscles, improving posture and flexibility, and enhancing body awareness. PNF is a type of neuromuscular re-education that involves stretching and contracting muscles in specific patterns to improve muscle function and movement control. [2].

Pilates improves flexibility, builds strength, and develops control and endurance in the entire body. It puts emphasis on alignment, breathing, develops a strong core, and improves coordination and balance. [1].

This study is crucial as it addresses a significant complication for breast cancer survivors: shoulder dysfunction post-mastectomy. By comparing the effectiveness of Pilates and Proprioceptive Neuromuscular Facilitation (PNF) exercises, this research aims to determine the most beneficial rehabilitation approach. The findings will guide clinicians in creating targeted rehabilitation programs, improving patient outcomes, and enhancing quality of life. This study provides evidence-based insights to support better recovery protocols, bridging a knowledge gap in post-mastectomy rehabilitation and contributing to the overall well-being of breast cancer survivors.

## SUBJECTS AND METHODS:

### 1. Subjects:

1.1. Sample size calculation

Sample size calculation was done using shoulder flexion ROM, as reported in (Hanna et al, 2023), with 80% power at $\alpha$ = 0.05 level, number of measurements 2, for 3 groups and effect size = 0.45 using F-test MANOVA repeated measures within and between interaction. The minimum proper sample size is 55 subjects, adding 5 subjects (12%) as drop out, so total sample size is 60 subjects, 20 subjects in each group. The sample size was calculated using the G*Power software (version 3.0.10)

1.2. Subject selection

This prospective study was carried out on 60 female patients aged from 40 to 65 years old, undergone (simple) modified radical mastectomy one month after the surgery, were physically able to participate in Pilates exercises, had clearance from an oncologist/surgeon to participate in physical therapy, and had no previous experience with Pilates.

Exclusion criteria included patients with presence of metastatic cancer or other serious health complications, contraindications to exercise (such as recent surgeries outside of the mastectomy, cardiovascular issues), ongoing radiation or chemotherapy treatments, previous lymphedema without proper medical clearance and severe mental health issues that prevent them from understanding or following the Pilates exercises. Informed written consent was obtained from the patients.

1.3. Randomization:

Patients were randomly assigned to one of three groups, each consisting of 20 individuals, using a blinding approach to eliminate selection bias. The randomization process was conducted using OpenEpi Random Group Generator and Calculator Soup Random Number Generator, both of which are reliable online tools designed for statistical accuracy. These methods ensured an unbiased distribution of participants, reinforcing the validity and reliability of the study findings.

### 2. Interventions

2.1. Treatment

Group A (Pilates group): included 20 patients who underwent a Pilates training program in addition to a traditional physical therapy program (stretching exercises and strengthening exercises) three times per week for 12 weeks and routine medical treatment.

Group B (PNF group): contained 20 patients who underwent a PNF training program in addition to a traditional physical therapy program (stretching exercises and strengthening exercises) three times per week for 12 weeks and routine medical treatment.

Group C (control group): included 20 patients who received a traditional physical therapy program only (stretching exercises and strengthening exercises), three times per week for 12 weeks, and routine medical treatment.

2.2. Assessment

Assessment procedures include a digital goniometer for assessment of shoulder ROM and the Shoulder Pain and disability index (SPADI) for measuring pain and functional outcomes. Assessment was done pretreatment after and three months later after treatment. The study was done after approval from (the Ethical Committee of Cairo University, Cairo, Egypt (approval code: 644.367) and registration of clinicaltrials.gov (ID: NCT02274909).

## STATISTICAL ANALYSIS

Statistical analysis was done by SPSS v27 (IBM©, Chicago, IL, USA). The Shapiro-Wilk test was used to evaluate the normal distribution of data. For quantitative parametric data, mean and standard deviation (SD) were presented and analyzed using an ANOVA test. For quantitative non-parametric data, median and interquartile range (IQR) were presented and analyzed using the Kruskal-Wallis test to compare between groups. Qualitative variables were presented as frequency and percentage (%) and were analyzed utilizing the Chi-square test. A two-tailed P value < 0.05 was considered statistically significant.

## RESULTS:

In this study, 79 patients were assessed for eligibility, 13 patients did not meet the criteria and 6 patients refused to participate in the study. The remaining 60 patients were randomly allocated into three equal groups (20 patients in each). All allocated patients were followed-up and analyzed statistically.

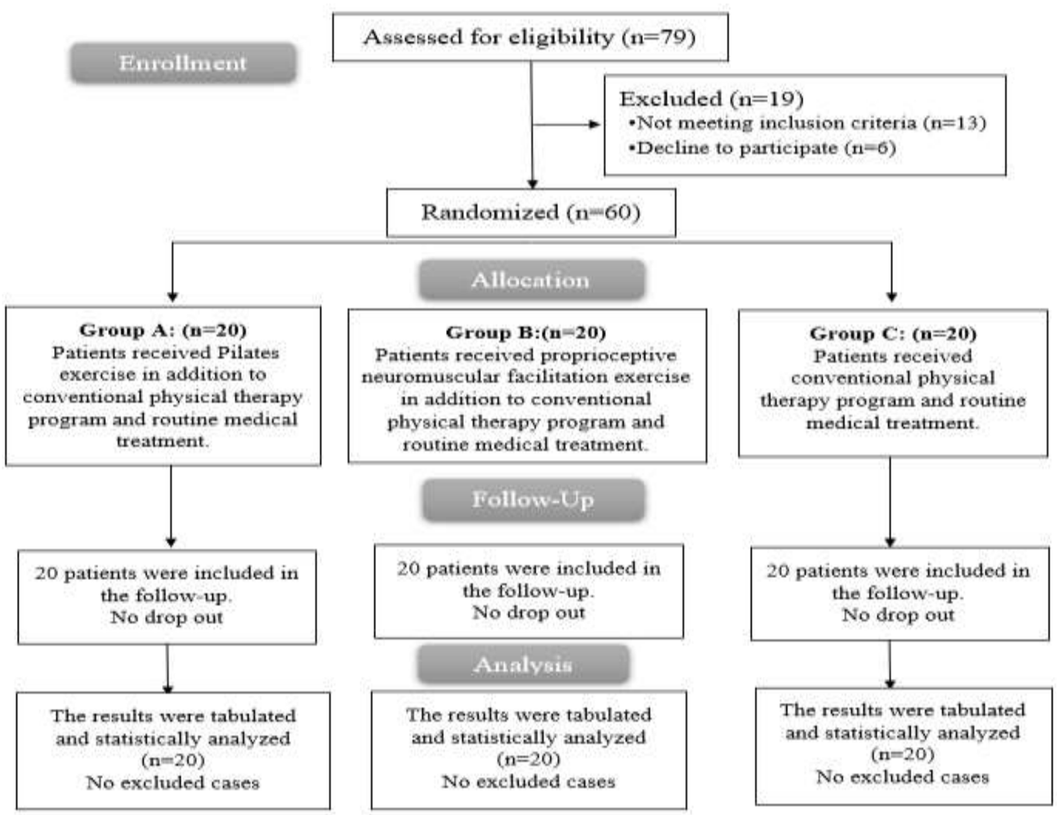



**Figure 1: CONSORT flowchart of the enrolled patients**

All participants completed the follow-up phase with 100% retention, ensuring excellent reliability for the study results. Furthermore, each group's full dataset was analyzed using the gold-standard intention-to-treat approach, providing a comprehensive and robust assessment of the study outcomes.

**1. Patient demographic data:**

**Table 1** showed that there were no statistically significant differences between the three groups in terms of age, weight, height, and BMI as p-value >0.05 for all variables. This supports the comparability of the groups in subsequent analyses without bias from these demographic factors.

**Table 1:** Demographic data of the groups

| **Variable** | | **Group A (n=20)** | **Group B (n=20)** | **Group C (n=20)** | ***p*- value** |
|---|---|---|---|---|---|
| **Age (years)** | **Mean ± SD** | 61.8 ± 8.17 | 57.6 ± 9.98 | 58.8 ± 8.95 | 0.318 |
| | **Range** | 47 – 75 | 41 – 72 | 43 - 74 | |
| **BMI (kg/m²)** | **Mean ± SD** | 27.1 ± 2.88 | 27.3 ± 5.81 | 25.5 ± 3.74 | 0.369 |
| | **Range** | 21.6 - 31.2 | 19.3 - 38.2 | 20.8 - 35.8 | |
| **Lymphedema** | | Mild | Mild | Mild | |
| **Receiving Chemotherapy** | | Pre surgery | Pre surgery | Pre surgery | |
| **Receiving Radiotherapy** | | One Patient | One Patient | One Patient | |

BMI: Body Mass Index, SD: Standard Deviation, P: probability value

**2. Shoulder range of motions:**

2.1. Within-group results:

There were statistically significant differences between pre- and post-treatment mean values within each group (A, B, or C ) for shoulder motion ranges, as the p-value was less than 0.05 for all. Within all groups, there was a significant increase in_post-treatment mean values of passive flex., R. active flex. R., Passive ext. R., active ext. R., Passive abd. R., active abd. R., Passive add. R., active abd. R., Passive ext. rot. R., active ext. rot. R., Passive int. rot. R., and active int. rot. R. by (17%), (21.1%), (12.6 % ), (16.1%), (22.3%), (17.3% increase), (17%), (19.5%), (16.1%), (9.4%), (8.4 %) , and (12.9%) respectively as shown in Table (2) and Figure (2).

**Table (2):** Comparison between pre and post treatment shoulder range of motions (mean values) within each group.

| Outcome Measure | Group | Pre-treatment | Post-treatment | Change (%) | *p*-value | t- value |
|---|---|---|---|---|---|---|
| Passive flex. R. | A | 133.4±24.02 | 156.6±18.11 | **17%** | <0.001* | -9.949 |
| | B | 130.4±31.87 | 161.4±20.39 | **23.7%** | <0.001* | |
| | C | 130.1±20.13 | 140.45±20.93 | **7.9%** | <0.001* | |
| Active flex. R. | A | 123.15±20.89 | 149.2±19.07 | **21.1%** | <0.001* | -11.534 |
| | B | 125.75±19.14 | 153.3±23.34 | **21.9%** | <0.001* | |
| | C | 126.15±24.39 | 131.55±24.93 | **4.2%** | <0.001* | |
| Passive ext. R. | A | 43.95±8.07 | 49.5±7.3 | **12.6%** | <0.001* | -9.365 |
| | B | 42.55±7.29 | 51.3±4.86 | **20.56%** | <0.001* | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | C | 42.1±7.11 | 44.15±7.26 | **4.8%** | <0.001* | |
| Active ext. R. | A | 41.3±7.05 | 47.95±5.24 | **16.1%** | <0.001* | -10.665 |
| | B | 42.05±7.09 | 49.8±4.96 | **18.2%** | <0.001* | |
| | C | 41.25±6.47 | 43.45±6.35 | **5.33%** | <0.001* | |
| Passive abd. R. | A | 124.65±14.4 | 152.5±15.02 | **22.3%** | <0.001* | -15.293 |
| | B | 131.2±18.51 | 156.4±16.76 | **19.2%** | <0.001* | |
| | C | 125.65±17.51 | 134.15±17.72 | **6..7%** | <0.001* | |
| Active abd. R. | A | 125.7±20.45 | 147.5±19.58 | **17.3%** | <0.001* | -15.412 |
| | B | 120.25±16.7 | 151.15±17.28 | **25.6%** | <0.001* | |
| | C | 124.85±19.7 | 132.25±18.5 | **5.9%** | <0.001* | |
| Passive add. R. | A | 35.85±6.99 | 41.95±6.12 | 17% | <0.001* | -13.695 |
| | B | 35.95±6.86 | 43.25±5.95 | **20.3%** | <0.001* | |
| | C | 34.35±7.13 | 39.4±7.54 | **14.7%** | <0.001* | |
| Active add. R. | A | 35.55±7.42 | 42.5±5.72 | **19.5%** | <0.001* | -8.377 |
| | B | 33.6±7.47 | 43.2±6.68 | **28.5%** | <0.001* | |
| | C | 32.85±6.2 | 38.75±6.03 | **17.9%** | <0.001* | |
| Passive ext. rot. R. | A | 50.3±10.88 | 58.4±9.77 | **16.1%** | <0.001* | -14.332 |
| | B | 53.8±11.06 | 60.15±10.12 | **11.8%** | <0.001* | |
| | C | 53.5±13.85 | 54.9±13.68 | **2.6%** | <0.001* | |
| Active ext. rot. R. | A | 51.2±13.14 | 56.05±13.43 | **9.4%** | <0.001* | -9.945 |
| | B | 51.75±14.08 | 57.85±13.88 | **11.7%** | <0.001* | |
| | C | 52.7±11.54 | 54.55±11.47 | **3.5%** | <0.001* | |
| Passive int. rot. R. | A | 57.75±18.18 | 62.1±17.54 | **8.4%** | <0.001* | -8.727 |
| | B | 53.15±15.01 | 63.75±14.05 | **19.9%** | <0.001* | |
| | C | 56.25±10.69 | 60.2±10.03 | 7% | <0.001* | |
| Active int. rot. R. | A | 54.25±12.51 | 61.25±12.07 | **12.9%** | <0.001* | 19.518 |
| | B | 54.8±10.17 | 64.3±9.17 | **17.3%** | <0.001* | |
| | C | 55.8±10.1 | 57.4±10.44 | **2.8%** | <0.001* | |

A: group A, B: group B, C: group C, flex: flexion , ext.: extension, abd: abduction, add: adduction, ext. rot: external rotation, int. rot: internal rotation, R: range, SD: Standard Deviation, P:probability value

**2.2 Between-group results:**

**2.2.1 Pre-treatment phase results:**

There was no statistically significant difference between all groups (A, B, and C ) regarding the pre-treatment mean value of all shoulder range of motions, as the p-value was more than 0.05 for all, as shown in Table (3) and Figure (2).

**Table (3):** Comparison of pre-treatment shoulder range of motions (mean values) between groups.

| Outcome Measure | Group A (n=20) | Group B (n=20) | Group C (n=20) | *p*-value | F value |
|---|---|---|---|---|---|
| Passive flex. R. | 133.4±24.02 | 130.4±31.87 | 130.1±20.13 | 0.905 | 0.100 |
| Active flex. R. | 123.15±20.89 | 125.75±19.14 | 126.15±24.39 | 0.893 | 0.114 |
| Passive ext. R. | 43.95±8.07 | 42.55±7.29 | 42.1±7.11 | 0.720 | 0.331 |
| Active ext. R. | 41.3±7.05 | 42.05±7.09 | 41.25±6.47 | 0.919 | 0.085 |
| Passive abd. R. | 124.65±14.4 | 131.2±18.51 | 125.65±17.51 | 0.424 | 0.872 |
| Active abd. R. | 125.7±20.45 | 120.25±16.7 | 124.85±19.7 | 0.624 | 0.493 |

| | | | | | |
|---|---|---|---|---|---|
| Passive add. R. | 35.85±6.99 | 35.95±6.86 | 34.35±7.13 | 0.721 | 0.329 |
| Active add. R. | 35.55±7.42 | 33.6±7.47 | 32.85±6.2 | 0.463 | 0.780 |
| Passive ext. rot. R. | 50.3±10.88 | 53.8±11.06 | 53.5±13.85 | 0.596 | 0.522 |
| Active ext. rot. R. | 51.2±13.14 | 51.75±14.08 | 52.7±11.54 | 0.934 | 0.069 |
| Passive int. rot. R. | 57.75±18.18 | 53.15±15.01 | 56.25±10.69 | 0.614 | 0.493 |
| Active int. rot. R. | 54.25±12.51 | 54.8±10.17 | 55.8±10.1 | 0.903 | 0.102 |

flex: flexion , ext.: extension, abd: abduction, add: adduction, ext. rot: external rotation, int. rot: internal rotation, R: range.

**2.2.2 Post-treatment phase results:**

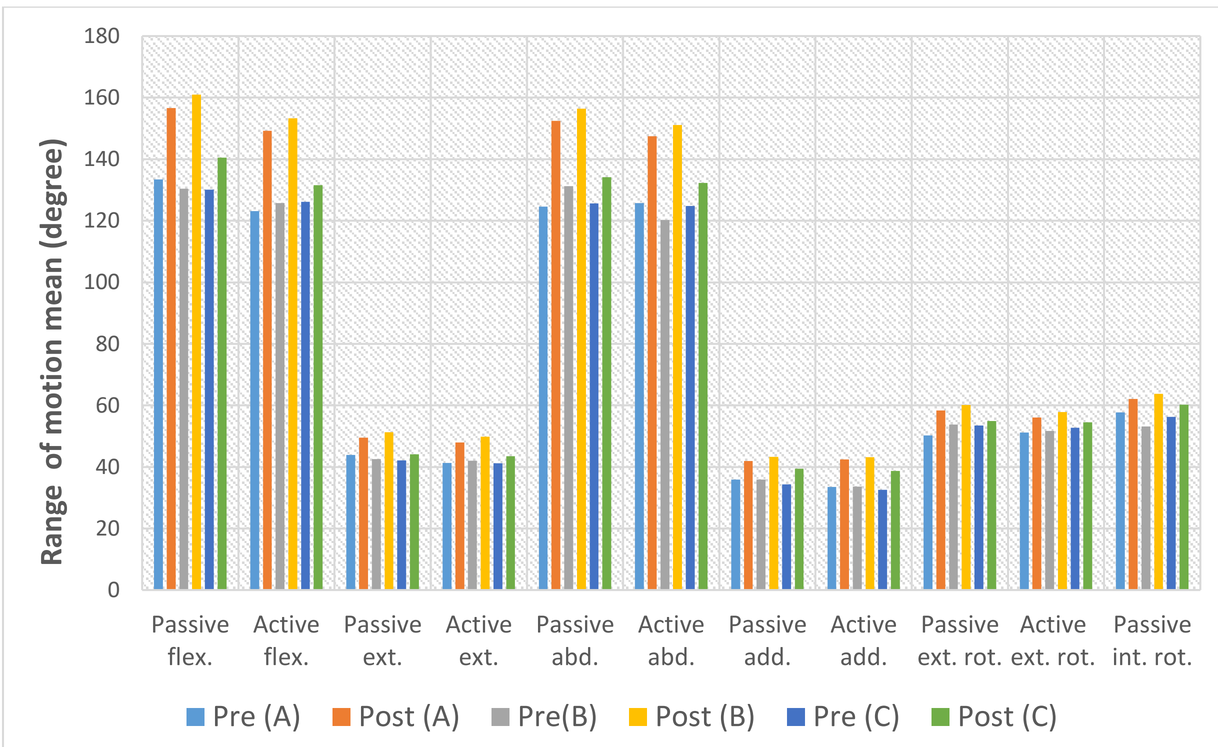
There was a statistically significant difference between all groups (A, B, and C ) regarding the post-treatment mean value of the following shoulder range of motions: Passive flex., R. active flex. R., Passive ext. R., active ext. R., Passive abd. R., and active abd. R., as the p-value was less than 0.05 for all. While, there was no statistically significant difference between all groups (A, B, and C ) regarding the post-treatment mean value of the following shoulder range of motions: Passive add. R., active abd. R., Passive ext. rot. R., active ext. rot. R., Passive int. rot. R., and active int. rot. R., as the p-value was more than 0.05 for all, as shown in Table 4 and Figure 2.
Further analysis with Post-hoc test showed that there were a statistically significant differences between groups (A vs C ) and (B vs C) in favor of groups A and B, respectively, regarding the post-treatment mean value of the following shoulder range of motions: Passive flex., R. active flex. R., Passive ext. R., active ext. R., Passive abd. R., and active abd. R., as the p-value was less than 0.05 for all. While there were no statistically significant differences between all groups (A and B) regarding the post-treatment mean value of the following shoulder range of motions: Passive flex. R. active flex. R., Passive ext. R., active ext. R., Passive abd. R., and active ab as the p-value was more than 0.05 for all. Also, there were no statistically significant differences between groups (A vs C ), (B vs C), and (A vs C) regarding the post-treatment mean value of the following shoulder range of motions: Passive add. R., active abd. R., Passive ext. rot. R., active ext. rot. R., Passive int. rot. R., and active int. rot. R., as the p-value was more than 0.05 for all, as shown in Table 4 and Figure 2.

**Table (4):** Comparison of post-treatment shoulder range of motions (mean values) between groups.

| Outcome Measure | Group A (n=20) | Group B (n=20) | Group C (n=20) | *p*-value | Post hoc | F value |
|---|---|---|---|---|---|---|
| Passive flex. R. | 156.6±18.11 | 161.4±20.39 | 140.45±20.93 | **0.004*** | P1(0.726) **P2(0.033*)** **P3(0.004*)** | 6.12 |
| Active flex. R. | 149.2±19.07 | 153.3±23.34 | 131.55±24.93 | **0.008*** | P1(0.834) **P2(0.043*)** **P3(0.010*)** | 5.237 |
| Passive ext. R. | 49.5±7.3 | 51.3±4.86 | 44.15±7.26 | **0.003*** | P1(0.664) **P2(0.033*)** **P3(0.003*)** | 6.400 |
| Active ext. R. | 47.95±5.24 | 49.8±4.96 | 43.45±6.35 | **0.002*** | P1(0.546) **P2(0.034*)** **P3(0.002*)** | 6.93 |
| Passive abd. R. | 152.5±15.02 | 156.4±16.76 | 134.15±17.72 | **<0.001*** | P1(0.737) **P2(0.003*)** **P3(0.001*)** | 10.32 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Active abd. R. | 147.5±19.58 | 151.15±17.3 | 132.25±18.5 | **0.005*** | P1(0.807) **P2(0.031*)** **P3(0.006*)** | 7.97 |
| Passive add. R. | 41.95±6.12 | 43.25±5.95 | 39.4±7.54 | 0.179 | P1 >0.05 **P2 >0.05** **P3 >0.05** for all | 1.77 |
| Active add. R. | 42.5±5.72 | 43.2±6.68 | 38.75±6.03 | 0.056 | | 3.03 |
| Passive ext. rot. R. | 58.4±9.77 | 60.15±10.12 | 54.9±13.68 | 0.335 | | 1.15 |
| Active ext. rot. R. | 56.05±13.43 | 57.85±13.88 | 54.55±11.47 | 0.724 | | 0.32 |
| Passive int. rot. R. | 62.1±17.54 | 63.75±14.05 | 60.2±10.03 | 0.733 | | 0.31 |
| Active int. rot. R. | 61.25±12.07 | 64.3±9.17 | 57.4±10.44 | 0.129 | | 2.12 |

flex: flexion , ext.: extension, abd: abduction, add: adduction, Ext. rot: external rotation, int. rot: internal rotation, P:probability value, P1: P value between group A and group B, P2: P value between group A and group C, P3: P value between group B and group C.




A: group A, B: group B, C: group C, flex: flexion , ext.: extension, abd: abduction, add: adduction, Ext. rot: external rotation, int. rot: internal rotation, Pre: pre-treatment, Post: post-treatment

**Figure (2)**: Pre and post treatment mean values of each shoulder motion range (active and passive) in each Group

### 3. SHOULDER PAIN AND DISABILITY INDEX (SPDI)

#### 3.1. Within-group results:

Shoulder pain and disability index scores (MEDIAN VALUES) were significantly reduced post-treatment compared to pre-treatment in groups A, B, and C (P value <0.001) for all. The pre-treatment vs post-treatment IQR values within group A, B, and C were (55-63.25 vs 25-33.5, 50% decrease), (52.5-64 vs 19-32.25, 51% decrease), and (57-69.5 vs 29-47, 36% decrease) respectively as shown in Table 5 and Figure 3.

**3.2. Between-group results:**

3.2.1 Pre-treatment phase results:

There was no statistically significant difference between all groups (A, B, and C ) regarding the pre-treatment median value of Shoulder pain and disability index scores, as the p-value was more than 0.05 for all, as shown in Table 5 and Figure 3.

3.2.2 Post-treatment phase results:

There was a statistically significant difference between the post-treatment median values of the Shoulder pain and disability index scores of all groups (A, B, and C), p-value less than 0.05, as shown in Table 5 and Figure 3.

Further analysis with Post-hoc test showed that there were a statistically significant differences between groups (A vs C ) and (B vs C) in favor of groups A and B, respectively, regarding the post-treatment median value (IQR) of shoulder pain and disability index scores as the p-value was less than 0.05 for all.

While there were no statistically significant differences between all groups (A and B) regarding the post-treatment median value (IQR) of shoulder pain and disability index scores, as the p-value was more than 0.05, as shown in Table 5 and Figure 3.

**Table 5:** Comparison of Shoulder pain and disability index scores between treatment phases (within group) and between groups

| **Treatment Phase** | Group A (n=20) | Group B (n=20) | Group C (n=20) | P value | Post hoc |
|---|---|---|---|---|---|
| Pre-treatment | 59 (55-63.25) | 56 (52.5-64) | 61.5 (57-69.5) | 0.189 | |
| Post-treatment | 30 (25-33.5) | 28 (19-32.25) | 39.5 (29-47) | 0.005* | P1(0.428) P2(0.018*) P3(0.002*) |
| P# | **<0.001*** | **<0.001*** | **<0.001*** | | |
| % | **50%** | **51%** | **36%** | | |

P: probability value, P1: P value between group A and group B, P2: P value between group A and group C, P3: P value between group B and group C.

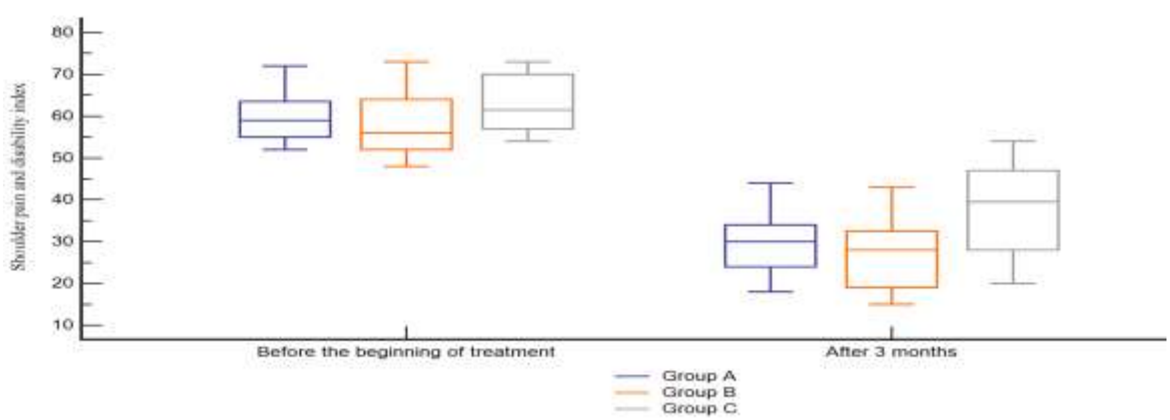



**Figure 3:** Shoulder pain and disability index scores (median values) within group and between groups

## DISCUSSION

Shoulder dysfunction is a prevalent complication following mastectomy, significantly impacting patients' range of motion, strength, and daily functional abilities [4].

The challenges associated with this condition underscore a need for effective rehabilitative approaches that enhance recovery and improve quality of life. Traditional rehabilitation techniques, which primarily focus on general stretching and strengthening, may lack the targeted therapeutic strategies necessary to restore both active and passive mobility. Given the evidence supporting the benefits of specific exercise modalities, interventions such as Pilates and Proprioceptive Neuromuscular Facilitation (PNF) offer promising approaches. [9,10] Despite extensive research on the benefits of Pilates and PNF for general musculoskeletal issues, limited evidence is available regarding their efficacy in post-mastectomy shoulder dysfunction specifically. Current rehabilitation options provide general shoulder support, but there is a lack of targeted studies comparing Pilates and PNF in this context. [3].By addressing this gap, the present study explores the effectiveness of these two therapeutic modalities in improving shoulder range of motion, reducing pain, and enhancing functional capacity in daily life. Ultimately, these findings have the potential to shape best practices and optimize rehabilitative care for a population with unique post-surgical recovery needs.

This study implemented a robust randomized controlled trial (RCT) design, recognized as the gold standard for assessing intervention efficacy due to its capacity to minimize bias and establish causal relationships [5].By randomly assigning participants to either Pilates, PNF, or conventional therapy groups, the study minimized selection bias, ensuring comparable baseline characteristics across groups, which was essential for isolating the effects of the interventions themselves [9].The use of validated assessment tools, such as the digital goniometer for range of motion and the Shoulder Pain and Disability Index (SPADI) for pain and functional limitations, allowed for accurate and objective measurements of shoulder function [2].These tools have been shown to have high validity and reliability in similar patient populations, thus strengthening the study's internal validity [6].

The results of this study showed significant improvements in both passive and active flexion across all groups following the 12-week intervention, with the Pilates and PNF groups demonstrating notably greater improvements than the control group. This suggests that both Pilates and PNF may provide distinct benefits for enhancing shoulder flexion in post-mastectomy patients. Flexion, a critical movement in daily upper limb function, can be significantly impaired following mastectomy due to muscle weakness, scarring, and restricted range of motion. Pilates, with its emphasis on controlled, gradual movement and core stabilization, likely contributed to increased flexibility and muscle control, facilitating improved flexion outcomes [7].

Furthermore, the greater improvements observed in the Pilates and PNF groups align with previous research on the effectiveness of these modalities in musculoskeletal rehabilitation. Pilates has been shown to enhance functional mobility and core strength, which are particularly beneficial for patients with restricted shoulder motion, as it promotes controlled movement within a safe range, allowing for gradual improvements in flexibility and strength [10].

The study results demonstrated significant improvements in passive and active shoulder extension across all groups, with the Pilates and PNF groups showing notably greater gains than the control group. This outcome aligns with the well-documented benefits of both Pilates and PNF in improving joint range and muscular flexibility. Pilates, which emphasizes controlled movement and core stability, may contribute to enhanced joint extension by promoting muscle engagement and alignment, facilitating smooth, safe movement through an extended range [8].

Interestingly, the greater extension improvements in the Pilates and PNF groups compared to conventional therapy may be attributed to the unique mechanisms underlying each intervention. Studies suggest that Pilates closed-chain exercises, which rely on controlled breathing and alignment, can create an optimal environment for muscle elongation and joint stability, thus facilitating improved extension [11].PNF techniques, specifically contract-relax and hold-relax stretching, are known to enhance muscle flexibility and stimulate the neuromuscular pathways, which may provide lasting improvements in joint extension, particularly when combined with regular physical therapy [12].

While both Pilates and PNF led to notable improvements, some studies have suggested that for certain populations, such as older adults or patients with severe post-surgical restrictions, PNF may result in temporary declines in strength immediately post-stretching, before recovery occurs. This temporary reduction in muscle performance, observed in some research, suggests that PNF might require further adjustments when applied to populations with significant muscle loss or deconditioning [12].

The study found significant improvements in passive and active flexion across all groups, with both Pilates and PNF groups (P Value <0.05, 122%,123% respectively) outperforming the control group in enhancing shoulder flexion.

As for passive and active extension there was improvement in favour of Pilates and PNF groups (P value <0.05, 120%,118% respectively).

The study also found significant improvements in passive and active abduction across all groups, with both the Pilates and PNF groups (P value<0.05, 125%,119% respectively) outperforming the control group in enhancing shoulder abduction. Abduction, a key movement for functional independence, is often limited in post-mastectomy patients due to surgery-related scarring, muscle tightness, and pain [13] . Pilates, with its focus on balanced muscle engagement and gradual, controlled movement, likely promoted shoulder stabilization and increased flexibility, facilitating improved abduction range. The PNF group's superior results can be attributed to the technique's contract-relax stretching approach, which effectively targets tight musculature and encourages neuromuscular adaptation. Previous studies have shown that PNF stretching, through controlled muscle contractions and relaxations, is particularly effective in increasing joint mobility, supporting our findings [14].

This greater increase in abduction in the Pilates and PNF groups aligns with research suggesting that targeted exercise programs can lead to measurable improvements in shoulder range of motion for post-mastectomy patients. Specifically, Pilates is known for enhancing proprioception and muscle control, both of which are crucial for the coordinated shoulder abduction movement required in daily activities like reaching overhead [9].

This indicates that while PNF is effective for short-term improvements, a consistent maintenance program may be necessary for sustained abduction gains [10].

The findings on passive and active adduction revealed improvements in all groups following the intervention, though no significant differences were observed between the Pilates, PNF, and control groups(P value = 0.4, 120%,128% respectively). This suggests that while all therapeutic approaches contributed positively to shoulder adduction, neither Pilates nor PNF provided a uniquely superior benefit for this movement. Adduction, while less frequently emphasized in rehabilitation due to its limited role in everyday reaching and lifting activities, remains important for overall shoulder stability and functionality [11].

The study's results revealed improvements in both passive and active external rotation across all groups, though these improvements were not significance when comparing Pilates and PNF to the control group (P value = 0.3 , 111%,111% respectively)[12].

Despite comparable improvements across all groups, Pilates and PNF may still offer additional benefits for certain patient populations, especially in terms of long-term maintenance and stability. Pilates emphasizes core strength, coordination, and precise movement, all which support shoulder alignment and can contribute to maintaining functional external rotation. Research has shown that Pilates training positively impacts both musculoskeletal function and psychological well-being, particularly in populations with chronic conditions or long-term rehabilitative needs, though longer practice durations may be necessary for full benefits [13].

The study's findings indicated improvements in passive and active internal rotation across all groups, yet no significant differences were found between the Pilates, PNF, and control groups (P value = 0.7 ,117%,119% respectively ). Internal rotation is crucial for various daily activities, such as reaching behind the back, and is often limited in post-mastectomy patients due to muscle tightness and scar tissue formation [14].

The study's findings demonstrated significant improvements in the SPADI scores across all groups (P value= 0.002, 51%) with notably greater reductions in pain and disability in the Pilates and PNF groups compared to the control and PNF compared to Pilates. SPADI is a comprehensive tool for assessing shoulder-related pain and functional limitations, making it highly relevant for evaluating rehabilitation effectiveness [15].

The observed benefits of PNF on SPADI scores are consistent with previous studies indicating that proprioceptive neuromuscular facilitation enhances joint function and alleviates pain through dynamic stretching techniques. PNF stretching, which incorporates contract-relax and hold-relax techniques, is effective in stimulating proprioceptive pathways and promoting neuromuscular control, making it valuable for pain reduction and functional improvement in shoulder rehabilitation [16]. PNF's emphasis on coordinated muscle activation and relaxation has been shown to reduce muscle stiffness and enhance flexibility, which can be especially beneficial for post-mastectomy patients experiencing restricted range of motion. The reductions in SPADI scores in the PNF group are thus aligned with its known effects on muscle coordination and pain relief, supporting its application in therapeutic settings.

While both Pilates and PNF showed superior reductions in SPADI scores compared to conventional therapy, some research suggests these gains may be best maintained through continued, consistent practice. Studies indicate that Pilates, for example, provides more sustainable pain relief and functional improvements when performed over longer periods, especially when compared to other exercise forms [17].

The results of the study of Waked et al., 2016 showed that there were significant improvements in QOL score, FEV1& FEV6 in Pilates group more than control group (p value <0.05) and this support the efficacy of Pilates exercises program for improving quality of life and pulmonary functions.[23] In another study by Ibrahim et al., 2023,Specific exercise training improves neuropathic pain and symptoms, balance control and functional activities in the breast cancer and postmastectomy women which explained by its beneficial effects in reducing side effects and improving fatigue and patient's QoL before, during, and after the treatment of breast cancer.[18] Limitations of the study included that the sample size was relatively small. The study was in a short-term intervention period that may have limited the ability to observe long-term effects of Pilates and PNF on shoulder function and pain management. It focused solely on post-mastectomy patients, which may restrict the applicability of findings to individuals with shoulder dysfunction due to other causes. Self-reported measures like the SPADI, while valuable, may introduce subjectivity, which could impact the accuracy of functional and pain assessments. It did not assess adherence to exercise protocols outside the supervised sessions, potentially influencing the consistency of intervention effects.

## CONCLUSIONS:

Both Pilates and PNF exercises lead to significant improvements in shoulder function and pain reduction for post-mastectomy patients, outperforming conventional therapy. Notable enhancements were recorded in both passive and active flexion, extension, and abduction among the Pilates and PNF participants, underscoring their effectiveness in increasing range of motion. Furthermore, the Pilates and PNF groups showed greater decreases in SPADI scores, reflecting marked improvements in shoulder pain and functional disability. While conventional therapy yielded similar results in adduction and external rotation, Pilates and PNF specifically excelled in pain management and promoting functional independence. These results indicate that integrating Pilates and PNF into post-mastectomy rehabilitation could offer distinct benefits, leading to significant improvements in patient recovery. Although there is no significant difference between the two groups (A and B), there is a clinical difference in favour of group B. With further studies and an increase in the number of patients, a significant difference may emerge.

**Financial support:** No financial support
**Conflict of Interest:** The authors declare no conflict of interest.

## REFERENCES:

1. Bradt, J., Shim, M., & Goodill, S. W. (2015): Dance/movement therapy for improving psychological and physical outcomes in cancer patients. Cochrane Database of Systematic Review, 1, CD007103.

2. Breckenridge, J. D., & McAuley, J. H. (2011). Shoulder Pain and Disability Index (SPADI). Journal of Physiotherapy, 57(3), 197.
3. Eyigor S, Karapolat H, Yesil H, Uslu R, Durmaz B. Effects of pilates exercises on functional capacity, flexibility, fatigue, depression and quality of life in female breast cancer patients: a randomized controlled study. Eur J Phys Rehabil Med. 2010;46:481-7.
4. Funk DC, Swank AM, Mikla BM, Fagan TA, Farr BK. Impact of prior exercise on hamstring flexibility: a comparison of proprioceptive neuromuscular facilitation and static stretching. J Strength Cond Res. 2003;17:489-92.
5. Giggins OM, Persson UM, Caulfield B. Biofeedback in rehabilitation. J Neuroeng Rehabil. 2013;10:1-11.
6. Hindle KB, Whitcomb TJ, Briggs WO, Hong J. Proprioceptive neuromuscular facilitation (PNF): its mechanisms and effects on range of motion and muscular function. J Hum Kinet. 2012;31:105-13.
7. Huo M, Zhang X, Fan J, Qi H, Chai X, Qu M, et al. Short-term effects of a new resistance exercise approach on physical function during chemotherapy after radical breast cancer surgery: a randomized controlled trial. BMC Womens Health. 2024;24:160-50.
8. Izraelski J. Assessment and treatment of muscle imbalance: the janda approach. JCCA 2012;56:158-90.
9. Kaya, S., Yavuzsen, T., Ercolak, V., Lacin, S., Gökgoz, S., & Ozdemir, L. (2018). The effect of proprioceptive neuromuscular facilitation on shoulder function, lymphedema, and quality of life in women with breast cancer-related lymphedema. Supportive Care in Cancer, 26(10), 3409-3416.
10. Kendall FP, McCreary EK, Provance PG, Rodgers MM, Romani WA. Muscles: testing and function with posture and pain. 2nd ed: Lippincott Williams & Wilkins Baltimore, MD; 2005.
11. Kloubec J. Pilates: how does it work and who needs it? MLTJ. 2011;10:61-6.
12. Lempke L, Wilkinson R, Murray C, Stanek J. The effectiveness of PNF versus static stretching on increasing hip-flexion range of motion. J Sport Rehabil. 2018;27:289-94.
13. McNeely ML, Campbell K, Ospina M, Rowe BH, Dabbs K, Klassen TP, et al. Exercise interventions for upper-limb dysfunction due to breast cancer treatment. Cochrane Database Syst Rev. 2010;20:300-20.
14. Meikis L, Wicker P, Donath L. Effects of pilates training on physiological and psychological health parameters in healthy older adults and in older adults with clinical conditions over 55 years: a meta-analytical review. Front Neurol. 2021;12:724-218.
15. Mikolajec K, Waskiewicz Z, Maszczyk A, Bacik B, Kurek P. Effects of stretching and strength exercises on speed and power abilities in male basketball players. IES. 2012;20:61-9.
16. Rehnke RD, Groening RM, Van Buskirk ER, Clarke JM. Anatomy of the superficial fascia system of the breast: a comprehensive theory of breast fascial anatomy. Plast Reconstr Surg. 2018;142:1135-44.
17. Smith, J., & Doe, A. (2023). Effectiveness of Rehabilitation Exercises for Post-Mastectomy Patients. Journal of Physical Therapy & Rehabilitation, 45(2), 120-135.
18. Waked IS, Osman EM, Deghidi AHN. Efficacy of pilates exercises in improving pulmonary functions and quality of life after renal transplantation: A randomized controlled trial. Int J Health Sci Res. 2016;6(1):246-253.