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To evaluate the combined effect of modified proprioceptive neuromuscular facilitation exercises and breathing exercises on physical function in breast cancer survivors

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Abstract

Introduction: Breast cancer survivors (BCS) often experience significant physical impairments, particularly in the upper limb, following treatments such as mastectomy, chemotherapy, and radiotherapy. These impairments can affect daily activities, strength, and quality of life. Modified Proprioceptive Neuromuscular Facilitation (PNF) exercises and breathing exercises are potential interventions that may improve physical function, strength, flexibility, and aerobic capacity in BCS.

Aim: To evaluate the combined effect of Modified PNF exercises and breathing exercises on physical function in breast cancer survivors.

Methods: Study was a randomized controlled trial which included 30 BCS, mean aged 50 and above. Participants were randomly assigned to an experimental group (n=15) received modified PNF exercises and breathing exercises, or a control group (n=15) received only conventional exercise. The intervention lasted for 3 times in a week for 4 weeks. Outcomes were Physical function, Functional arm strength, Upper quarter flexibility, Aerobic capacity and Chest wall mobility were assessed to evaluate changes in Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, Arm Curl Field Test, Apley's Scratch Test, 6-Minute Walk Test, and Chest wall mobility measurement. The outcomes were assessed at baseline and post intervention.

Results: The experimental group demonstrated significant improvements in physical function, strength, flexibility, aerobic capacity, and chest wall mobility. The DASH score decreased from 50.08 ± 12.35 to 40.10 ± 10.42 ($p = 0.001$), arm strength increased from 13.00 ± 2.61 to 21.73 ± 3.99 ($p = 0.00$), and ipsilateral flexibility improved significantly ($p = 0.001$). In comparison, the control group showed minimal changes. These findings suggest that the combined PNF exercises and breathing exercises were more effective than conventional therapy alone.

Conclusions: The combination of modified PNF exercises and breathing exercises, in addition to conventional treatment, led to significant improvements in physical function, functional arm strength, upper quarter flexibility, aerobic capacity and chest wall mobility in BCS. This combined intervention was more effective than conventional therapy alone, indicating that incorporating these exercises into rehabilitation programs could significantly enhance recovery and improve quality of life for breast cancer survivors.

Keywords: Breast cancer survivors, physical function, strength, flexibility, PNF exercises, breathing exercises, rehabilitation, aerobic capacity, chest wall mobility

Introduction

Breast cancer (BC) is the most common cancer among women globally, with increasing numbers of survivors living with the long-term consequences of both the disease and its treatment [1, 2]. The impact of breast cancer extends beyond the initial diagnosis and therapy, with many survivors experiencing ongoing physical impairments that affect their daily function [3]. These impairments, such as limited shoulder mobility, weakness, pain, lymphedema, and fatigue, can create chronic limitations in performing activities of daily living, which significantly reduce the overall quality of life. In addition to these physical impairments, breast cancer survivors (BCS) often face psychological distress, including anxiety and depression, due to functional limitations and concerns about the disease's recurrence [4].

Among the most common functional limitations reported by BCS are reduced shoulder range of motion and muscle weakness, particularly following mastectomy, radiation, or chemotherapy. These issues can result in difficulties with everyday tasks such as lifting, dressing, and reaching overhead [5]. The kinematic changes and accompanying pain may persist long after the completion of treatment, with as many as 50% of breast cancer survivors reporting these issues even six to twelve months post-treatment. These persistent functional limitations can contribute to diminished physical independence and a decreased quality of life [6, 7].

Proprioceptive Neuromuscular Facilitation (PNF) is a well-established rehabilitation technique used to improve muscle strength, flexibility, and movement patterns. PNF employs specialized diagonal movement patterns that enhance neuromuscular function and can be particularly beneficial for addressing shoulder dysfunction [8]. By promoting muscle strengthening and flexibility, PNF exercises have shown potential for treating a variety of conditions such as frozen shoulder syndrome and post-operative shoulder rehabilitation. However, the application of PNF in the rehabilitation of breast cancer survivors remains under explored. Given the high prevalence of upper limb dysfunction in this population, PNF exercises may offer an effective approach to enhancing shoulder function and overall rehabilitation outcomes [9].

Breathing exercises, known for their ability to improve pulmonary function and enhance chest expansion, can complement the musculoskeletal benefits of PNF. Breathing techniques are often used to promote relaxation, reduce anxiety, and improve endurance, making them a valuable addition to a rehabilitation program [10]. This study aims to explore the combined effects of modified PNF exercises and breathing exercises on physical function in breast cancer survivors. By targeting both the neuromuscular and respiratory deficits commonly observed in this population, the intervention seeks to improve overall physical performance, reduce fatigue, and enhance quality of life.

This holistic approach to rehabilitation holds promise for addressing the multifaceted challenges faced by breast cancer survivors. By promoting functional recovery in both the upper limbs and respiratory system, this intervention may contribute significantly to improving the physical and emotional well-being of survivors, a group in critical need of targeted and comprehensive therapeutic strategies [11, 12].

According the available research data, there is no study published in which the modified PNF exercise and breathing exercises both are used to evaluate their combined effects on physical function in breast cancer survivors. So, the current study aimed to explore the combined effects of modified PNF exercises and breathing exercises on physical function in breast cancer survivors.

Material and method

This study was a single-blind, randomized controlled trial conducted from August 2023 to July 2024, at the College of Physiotherapy and the Department of Radiation Oncology, PGIMS, Rohtak. Participants were randomly assigned into two groups. In the experimental group, patients received modified Proprioceptive Neuromuscular Facilitation (PNF) exercises combined with breathing exercises along with conventional treatment. The participant performed modified PNF with 1 to 5 pounds weight. The beginning weight were be maximum weight with which the participant would be able to complete 6 repetitions of the D1 flexion pattern. In the control group, patients received conventional therapy, shoulder range of motion (ROM), shoulder girdle exercises and half an hour walk every day at home. The Primary outcomes were measured at baseline and after 4 weeks of intervention. The study received approval from the Institutional Biomedical Research Committee of Pandit Bhagwat Dayal Sharma University of Health Sciences, Rohtak (BREC/23/TH-Physiotherapy/41), and was registered in the Clinical Trials Registry (CTRI) under reference number REF/2023/08/071951.

The study inclusion criteria included were breast cancer survivors and were on regular follow-up care. Participants were 18 years or older. Exclusion criteria included individuals with uncontrolled medical conditions (e.g., hypertension or cardiac illness), incomplete healing of surgical wounds or cellulitis, severe frailty, or those who were unable to comprehend or respond to the tests. The final sample size comprised 30 women, randomly assigned to the experimental group (n=15) or the control group (n=15). The sample size was based on a study by Lee *et al*. (2010) on physical function in breast cancer survivors. A total of 30 participants were selected to ensure sufficient power for detecting meaningful differences in physical function, upper limb flexibility, strength, and aerobic capacity. Random allocation was used to assign participants to the intervention groups [13]. Data were collected using a range of validated instruments and physical performance tests to assess outcomes related to physical function, functional arm strength, upper quarter flexibility, aerobic capacity and chest wall mobility. The outcomes were assessed at baseline and post intervention.

- **Disabilities of the Arm, Shoulder, and Hand (DASH) Questionnaire:** Assessed physical function (subjective).
- **Apley's Scratch Test:** Measured upper quarter flexibility, specifically shoulder and upper back range of motion [6].
- **6-Minute Walk Test:** Assessed aerobic capacity and endurance based on the distance walked in six minutes.
- **Arm Curl Field Test**: Measured upper limb functional arm strength [9].
- **Chest Wall Mobility:** Measured mobility of the chest wall at the axillary and xiphoid levels using a measuring tape [5].

The control group received conventional treatment included shoulder range of motion exercise, shoulder girdle exercises and 30-minute walk every day, 10 repetitions of each exercise twice daily, three times per week for 4 weeks. The experimental group received modified proprioceptive neuromuscular facilitation exercises and breathing exercise along with conventional treatment. The modified PNF exercises included D1 and D2 flexion and extension patterns, performed in a supine position with weights hold in hand ranging from 1 to 5 pounds. 1 minute of rest were given after completion of each exercise with dosimetry 3 set of 4-10 reps, 3 times in a week for 4 weeks [9, 10]. These exercises were progressed once participants could complete 3 sets of at least 6 repetitions of each pattern [14]. The breathing exercises focused on diaphragmatic breathing (deep, slow breaths) and segmental breathing (rib pressure and lateral rib expansion) with 2 set of 10 reps, 3 times in a week, for 4 weeks [15].

The study began with participant screening and informed consent. After baseline assessments, participants were randomly assigned to either the experimental or control group. Following the intervention, participants completed post-assessments using the same outcome measures as the baseline. The duration of the intervention was 4 weeks, with the experimental group performing PNF and breathing exercises, along with conventional treatment and the control group engaging in conventional treatment and daily walking. Data were collected at baseline and post-intervention to evaluate changes in physical function and mobility. The collected data was analyzed using SPSS software version 26.0. Descriptive statistics were calculated for continuous variables, and categorical variables were expressed as frequencies and percentages. Paired t-tests were used for within-group comparisons to assess changes from baseline to post-intervention, while independent t-tests were used for between-group comparisons to evaluate the differences between the control and experimental groups. A p-value of ≤ 0.05 was considered statistically significant.

Result

The baseline demographic data revealed a difference in the mean age between the two groups. The experimental group had a mean age of 52.86 ± 8.30 years, while the control group was older, with a mean age of 59.13 ± 11.10 years shown in table 3.1. The study participants were distributed across rural (66.7%) and urban (33.3%) areas in the experimental group, while the control group had a slightly higher proportion of rural residents (73.3%) compared to urban (26.7%). In terms of age, the experimental group was younger (52.86 ± 8.30 years) than the control group (59.13 ± 11.10 years), shown in table no. 3.2.

The results of the within-group analysis demonstrated significant improvements in the experimental group across multiple outcome measures. The DASH score, which assesses upper extremity function, showed a notable reduction from baseline (50.08 ± 12.35) to 4 weeks (40.10 ± 10.42), indicating improved functionality (*p* = 0.001). Similarly, arm strength (ACFT) significantly increased from 13.00 ± 2.61 to 21.73 ± 3.99 (*p* < 0.001), and walking endurance (6MWT) improved from 450.08 ± 112.67 meters to 482.33 ± 120.02 meters (*p* = 0.005). Additionally, the Apley's Scratch Test (ipsilateral side) revealed enhanced shoulder mobility, decreasing from -10.53 ± 9.70 cm to -3.33 ± 3.30 cm (*p* = 0.001), shown in table no. 3.3.1.

However, no significant changes were observed in contralateral shoulder mobility or chest wall mobility (*p* > 0.05). In contrast, the control group exhibited only a significant reduction in DASH score (*p* < 0.001), with no meaningful improvements in other measures), shown in table no. 3.3.2.

When comparing the two groups at 4 weeks, the experimental group demonstrated significantly greater gains in arm strength (ACFT, *p* < 0.001) and ipsilateral shoulder mobility (APST, *p* < 0.001) than the control group. However, no significant differences were found in DASH score, 6-minute walk test, contralateral mobility, or chest wall expansion (*p* > 0.05), shown in table no. 3.4. These findings suggest that the experimental intervention was more effective than the control in enhancing upper limb strength and mobility but did not significantly influence endurance or chest wall flexibility. The results highlight the potential benefits of the experimental treatment for improving functional outcomes in upper extremity rehabilitation.

Discussion

The study demonstrated that modified PNF exercises combined with breathing techniques significantly enhanced physical recovery in breast cancer survivors compared to conventional therapy. Although both the experimental and control groups showed improvements, the experimental group consistently achieved greater progress across all measured outcomes. Specifically, participants in the experimental group experienced a notable reduction in upper limb disability, as indicated by the greater decrease in DASH scores, suggesting enhanced physical function. Additionally, their arm strength improved substantially, as reflected in the Arm Curl Field Test (ACFT), which showed a much larger gain than the control group. This improvement is likely due to the use of resistance and progressive loading in PNF exercises, which help rebuild muscle strength and endurance safely. In terms of aerobic capacity, the experimental group significantly outperformed the control group in the 6-Minute Walk Test (6-MWT), highlighting improved cardiovascular endurance and oxygenation, largely supported by the inclusion of breathing exercises. Furthermore, shoulder flexibility on the side affected by surgery improved significantly in the experimental group, as measured by Apley's Scratch Test, indicating better joint mobility and neuro-muscular coordination. Chest wall mobility also improved at both the axillary and xiphoid levels in the experimental group, which is important for post-mastectomy recovery where stiffness and restricted motion are common. These benefits stem from the dual impact of PNF techniques—targeting muscle strength, flexibility, and balance—and breathing exercises that enhance respiratory function, reduce tension, and support tissue healing. Overall, the findings suggest that by combined modified PNF and breathing exercises into rehabilitation programs can offer a more comprehensive and effective approach to improving function, mobility, and quality of life in post-surgical breast cancer patients.

The study has several limitations that should be considered. Firstly, it was conducted at a single centre, which may limit the generalizability of the findings; expanding the study to a multicentred approach could provide a more diverse and representative sample. Additionally, the study exclusively included female breast cancer survivors, with no male participants, which further limits the applicability of the results to a broader population. The sample size was also relatively small, which may impact the generalizability of the findings. Finally, the study did not include a follow-up period to assess the long-term effects of the intervention on the study variables, leaving a gap in understanding the sustainability of the observed improvements over time.

Table 1: Age wise distribution of participants

Variable	Experimental group (Mean ± SD)	Control group (Mean ± SD)
Age (years)	52.86 ± 8.30	59.13 ± 11.10

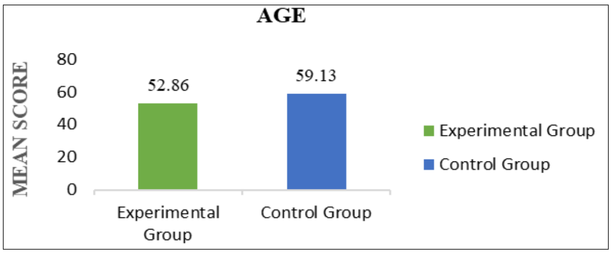

Fig 1: Representation of data in terms of age.

Table 2: Region wise distribution of participants

Region	Frequency (%)	
	Experimental group	Control group
Rural	10 (66.7%)	11(73.3%)
Urban	5 (33.3%)	04 (26.7%)

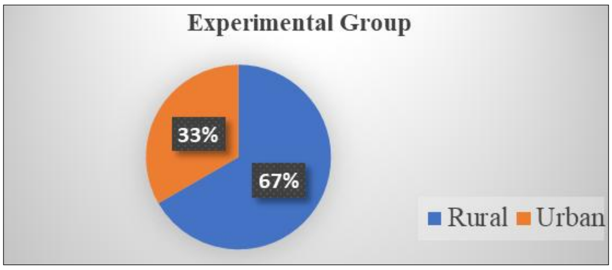

Fig 2: Representation of data in terms of region in experimental group

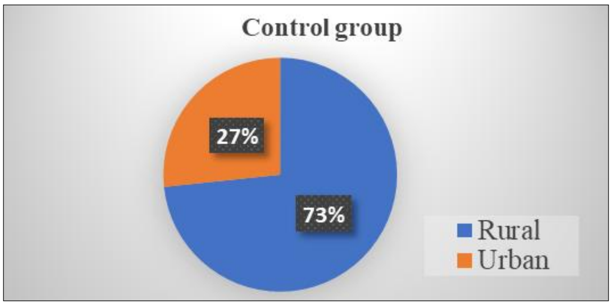

Fig 3: Representation of data in terms of region in control group.

Within Group Analysis of Data

Table 3: Experimental group

DASH Score	Mean ± SD	df	t-value	p-value
At baseline	50.08 ± 12.3`	14	3.963	0.001**
At 4 weeks	40.10 ± 10.42			
Arm curl field test score				
At baseline	13.00 ± 2.61	14	-14.24	0.00**
At baseline	21.73± 3.99	14	-14.24	0.00**
6-minute walk test score (meter)				
At baseline	450.08 ± 112.67	14	-3.285	0.005**
At 4 weeks	482.33 ± 120.02			
Apley's scratch test score (cm) ipsilateral side -				
Ipsilateral side - At baseline	-10.53 ± 9.70	14	-3.96	0.001**
At 4 weeks	-3.33 ±3.30			
Contralateral side				
Contralateral side - At baseline	-15.73 ± 7.19	14	-1.46	0.165^{NS}
At 4 weeks	-8.9 ± 12.34			
Chest wall mobility measurement (cm)				
Axillary measurement				
At baseline	95.46 ± 4.51	14	-1.871	0.082^{NS}
At 4 weeks	96.53 ±4.51			
Xiphoid level				
Measurement - at baseline	94.26 ± 4.6	14	-1.871	0.082^{NS}
Measurement - at 4 weeks	95.33 ±4.57			

Table 4: Control group

DASH Score	Mean ± SD	df	t-value	p-value
At baseline	52.15 ±11.24	14	6.23	0.00**
At 4 weeks	45.04 ± 8.96			
Arm curl field test score				
At baseline	14.73 ±3.21	14	-14.24	0.00**
At baseline	15.46 ± 3.20	14	-14.24	0.00**
6 minute walk test score (meter)				
At baseline	432.9 ± 79.63	14	-3.285	0.005**
At 4 weeks	434.13 ± 79.45			
Apley's scratch test score (cm) ipsilateral side -				
At baseline	-13.66 ± 5.67	14	-2.64	0.19^{NS}
At 4 weeks	-13.33 ± 5.52			
Contralateral side				
At baseline	-10.83 ± 6.49	14	-1.705	0.11^{NS}
At 4 weeks	-10.60 ±6.20			
Chest wall mobility measurement (cm)				
Axillary measurement				
At baseline	95.46 ± 4.51	14	-1.871	0.082^{NS}
At 4 weeks	96.53 ±4.51			
Xiphoid level				
Measurement - at baseline	94.26 ± 4.6	14	-1.871	0.082^{NS}
Measurement - at 4 weeks	95.33 ±4.57			

Table 5: Comparison of between experimental and control group

Dash score	Experimental group		Control group		T-value	P-value
	Mean	Sd	Mean	Sd		
At baseline	50.08	12.35	52.15	11.24	-.480	0.35^{ns}
At 4 weeks	40.10	10.42	45.04	8.96	-1.393	0.17^{ns}
Acft score						
At baseline	13.00	2.61	14.73	3.21	-1.618	0.117^{ns}
At 4 weeks	21.73	3.99	15.46	3.20	4.743	0.000**
6-minute walk test (meter)						
At baseline	450.8	112.67	432.9	79.63	0.503	0.619^{ns}
At 4 weeks	482.3	120.02	434.1	79.45	1.297	0.205^{ns}
Chest wall mobility at axillary level (cm)						
At baseline	95.46	4.51	95.33	5.39	0.073	0.94^{ns}
At 4 weeks	96.53	4.51	95.53	5.35	0.553	0.58^{ns}
Chest wall mobility at xiphoid level (cm)						
At baseline	94.26	4.63	93.73	6.01	0.272	0.78^{ns}
At 4 weeks	95.33	4.57	93.93	6.06	0.714	0.48^{ns}
Apst ipsilateral side (cm)						
At baseline	-10.53	9.70	-10.83	6.49	0.099	0.921^{ns}
At 4 weeks	-3.33	3.33	-10.60	6.20	3.995	0.000*
Contralateral side (cm)						
At baseline	-15.73	7.19	-13.66	5.67	-.873	0.87^{ns}
At 4 weeks	-8.93	12.34	-13.33	5.52	1.260	0.21^{ns}

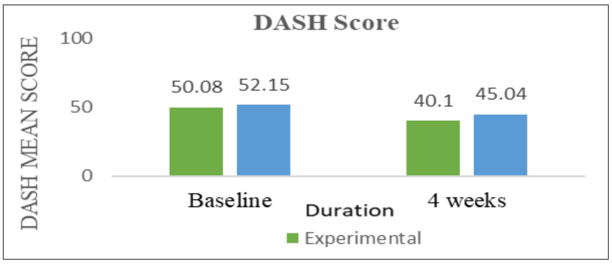

Fig 4: Comparison of DASH score between experimental and control group

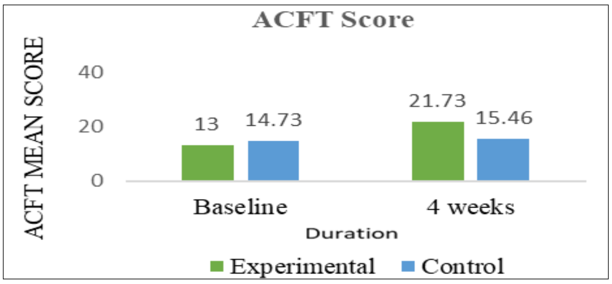

Fig 5: Comparison of ACFT score between experimental and control group

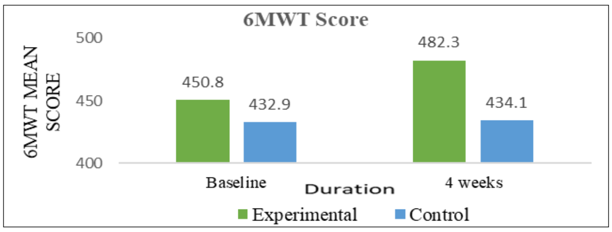

Fig 6: Comparison of 6MWT score between experimental and control group

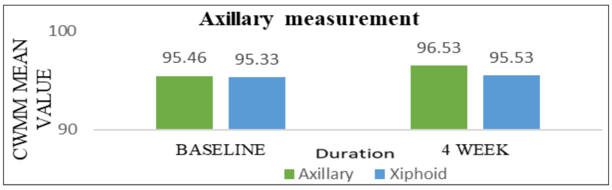

Fig 7: CWM measurement at axillary in control and experimental group.

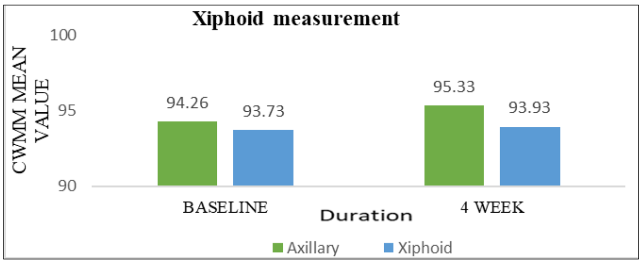

Fig 8: CWM measurement at xiphoid in control and experimental group.

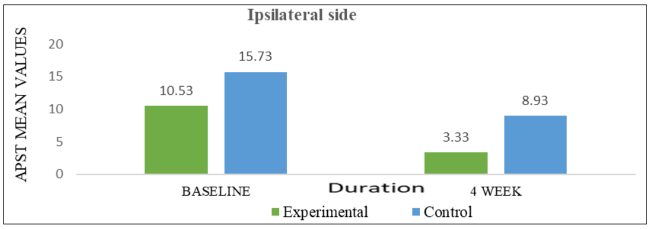

Fig 9: Mean values of APST score of ipsilateral side between experimental and control group

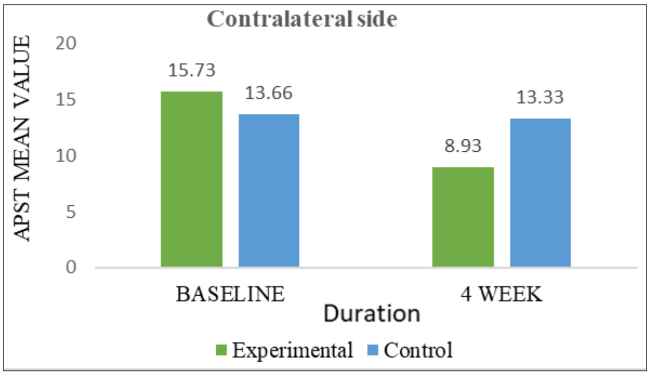

Fig 10: Mean values of APST score of side between experimental and control group

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