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Effectiveness of Proprioceptive Neuromuscular Facilitation Technique on Paclitaxel Chemotherapy Induced Motor Dysfunction and Activities of Daily Living in Breast Cancer Survivors. - A Randomized Controlled Trial

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ABSTRACT

Background: Breast cancer remains one of the most common cancers affecting women worldwide, with chemotherapy being a prevalent treatment modality. Among the various chemotherapeutic agents, Paclitaxel is widely used due to its efficacy in targeting cancer cells. However, despite its therapeutic benefits, Paclitaxel is associated with several adverse effects, including peripheral neuropathy, which can lead to significant motor dysfunction. his neuropathy manifests as muscle weakness, impaired coordination, and reduced fine motor skills. Motor dysfunction in breast cancer survivors undergoing Paclitaxel chemotherapy often translates to substantial difficulties in performing activities of daily living (ADLs). ADLs encompass essential self-care tasks such as bathing, dressing, eating, and mobility. Impairments in these areas can lead to increased dependence, decreased independence, and overall diminished quality of life. Proprioceptive Neuromuscular Facilitation (PNF) is a therapeutic approach that has shown promise in improving neuromuscular control and functional abilities. The methodology focuses on stimulating proprioceptors, which are sensory receptors that provide information about body position and movement. By engaging these receptors, PNF aims to improve the communication between the nervous system and muscles, thereby enhancing motor function and control. Despite the theoretical benefits, there is limited empirical evidence supporting the use of PNF specifically for Paclitaxel-induced motor dysfunction. This randomized controlled trial aims to fill this gap by rigorously evaluating the effectiveness of PNF in improving motor function and ADLs in breast cancer survivors. By providing robust data, this study seeks to establish PNF as a viable and effective rehabilitation option for this population, ultimately contributing to improved long-term outcomes and quality of life for breast cancer survivors.

Objective: To evaluate the effectiveness of Proprioceptive Neuromuscular Facilitation (PNF) in mitigating motor dysfunction and enhancing ADLs in breast cancer survivors treated with Paclitaxel.

Methods: This randomized controlled trial included 60 breast cancer survivors experiencing Paclitaxel-induced motor dysfunction. Participants were randomly assigned to either the intervention group, receiving PNF therapy, or the control group, receiving standard care. The intervention group underwent PNF sessions three times a week for 4 weeks. Outcomes were assessed using the and the Activities of muscle strength by 1 RM and ADLs by using L-IADLs before and after the intervention.

Results: The intervention group demonstrated significant improvements in 1RM compared to the control group ($p < 0.05$). Additionally, L-IADLs scores indicated a notable enhancement in the ability to perform daily activities for participants receiving PNF ($p < 0.05$). These improvements were observed as early as 4 weeks

Conclusion: PNF therapy is effective in reducing Paclitaxel-induced motor dysfunction and improving the quality of life by enhancing ADLs in breast cancer survivors. This therapeutic approach offers a viable rehabilitation option, potentially leading to better long-term functional outcomes for this population.

Keywords: *Proprioceptive Neuromuscular Facilitation, Paclitaxel, Motor Dysfunction, Activities of Daily Living, Breast Cancer Survivors,*

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1. INTRODUCTION

Cancer is a major global health concern and the primary cause of mortality for people worldwide [1]. It is often characterized by the fast growth of aberrant cells that spread beyond their normal limits [1]. The Indian Council of Medical Research (ICMR) National Cancer Registry Programme reports that between 2020 and 2022, India's cancer burden has increased, with a rise in both cancer cases and related deaths [2]. With 2.26 million cases, breast cancer became the most common type of cancer in 2020 [2] and, according to the annual highlight reports of 2022–2023 by National Centre for Disease Informatics and Research, Indian Council of Medical Research (ICMR), out of 1887 cases of breast cancer, 97.9% were diagnosed in females and 2.1% in males [3]. Women aged 45–49 and men aged 50–54 were the most common age groups for these diagnoses [3]. Breast cancer is generally indicated by symptoms like breast swelling or lump (mass), swelling in the armpit (lymph nodes), clear or bloody nipple discharge, nipple pain, inverted (retracted) nipple, scaly or pitted skin on the nipple, persistent breast tenderness, and unusual breast pain or discomfort [4,5].

There are numerous therapeutic methods available to treat breast cancer [6]. Surgery is frequently the first step in the treatment of breast cancer [6]. Most patients with breast cancer will get further treatment, such as hormone therapy, chemotherapy, and radiation therapy, following surgery. Chemotherapy is categorised in a few different ways. Chemotherapy is used as adjuvant therapy or as neoadjuvant therapy. It helps to decrease a tumour, delay the spread of the cancer, and improve the prognosis for breast cancer patients [6]. There are numerous choices for chemotherapy regimens from a reliable source. The type, stage, and aggressiveness of a patient's cancer, together with their overall health and the intended course of therapy, all influence which medications or combinations of medications to be used [4,6].

One class of chemotherapy known as a taxane is paclitaxel[7]. Because of its unique mechanism of action, it has generated considerable interest in the treatment of breast cancer [7]. Taxane disrupt the movement of chromosomes via structures in the cell called micro-tubules during mitosis, or cell division, by preventing cell division, paclitaxel inhibits the growth of cancer cells as well as other dividing cells [7]. However, paclitaxel's efficacy is constrained by a number of adverse effects related to its usage [8]. It has been observed that the incidence of paclitaxel-induced neuropathy, which includes motor impairment, varies from 10% to over 60%, contingent on treatment duration and dose, patient age, and underlying medical problems [9].

Paclitaxel, in its mechanism of inducing motor dysfunction, initiates a cascade of physiological responses within the body [9]. Primarily, it prompts an inflammatory reaction in muscle tissue by activating immune cells and releasing cytokines and other inflammatory mediators. This inflammatory response sensitizes nerve endings, exacerbating neuropathic pain and discomfort experienced by patients [9,10]. Furthermore, paclitaxel induces oxidative stress in muscle cells by promoting the generation of reactive oxygen species (ROS) while impairing antioxidant defense mechanisms [10]. This oxidative stress damages cellular structures such as proteins, lipids, and DNA. Additionally, the pathways mediated by oxidative stress may further intensify inflammation [10,11].

In addition to these effects, paclitaxel disrupts mitochondrial function in muscle cells by interfering with microtubule dynamics, which are crucial for proper sarcomere organization and function [11,12]. This disruption can lead to abnormalities in sarcomere structure and function, contributing to motor dysfunction. Moreover, paclitaxel affects calcium, sodium, and potassium channel function in various cell types, including muscle cells [13]. Altered channel activity can disrupt normal calcium dynamics, membrane potential, and excitability changes in muscle cells, ultimately affecting their ability to generate action potentials necessary for muscle contraction [13,14].

Disruption of microtubule dynamics by paclitaxel also indirectly affects the organization and function of actin and myosin filaments within muscle cells, leading to alterations in intracellular signalling pathways and cytoskeletal organization [15]. This might result in impairments in ATP synthesis, leading to reduced energy availability in muscle cells, thereby making muscles prone to dysfunction with symptoms of pain, muscle cramps, fatigue, and weakness. This can interfere with fine motor skills and make it difficult to perform activities of daily living (ADLs) like holding a pen, opening jars or bottles, picking up objects from higher shelves, climbing stairs, standing, walking and results into significant motor dysfunction [16,17,18].

Exercise plays vital role in the management and prevention of sensorimotor dysfunction in cancer patients for several important reasons. With targeted exercises, it helps to preserves the integrity of the neuromuscular system, enhances proprioception and aids in muscle building, thus improves endurance [19,20]. It also helps to mitigate adverse effects such as pain, fatigue and cachexia [21]. Furthermore, it enhances skills required for activities of daily living (ADLs) [22]. Moreover, engaging in exercise can empower patients, giving them a sense of control over their health and positively influencing their perception of motor dysfunction and their ability to manage the physical and functional challenges associated with cancer.

Cancer rehabilitation encompasses a multidisciplinary approach aimed at improving the physical, emotional, and functional well-being of individuals affected by cancer and its treatments. While various physiotherapy interventions have been explored to enhance strength and activities of daily life, one technique that remains under explored is Proprioceptive

Neuromuscular Facilitation (PNF).

Proprioceptive Neuromuscular Facilitation (PNF) exercises are a form of neuromuscular facilitation technique widely utilized in Rehabilitation settings. It differs from other conventional methods as it often involves manual facilitation by the therapist to guide movements and provide resistance or assistance as needed. This hands-on approach of PNF allows for precise control over movement patterns and facilitates neuromuscular re-education. PNF techniques involve complex movement patterns that engage proprioceptive feedback to improve coordination and motor control [23]. Also, it utilizes diagonal patterns of movement that involve multiple joints and muscle groups working together synergistically. These multidimensional movements mimic functional activities and help integrate sensory and motor pathways. It helps to provide progressive resistance to the muscles, gradually by increasing the challenge as the patient's strength improves [23]. This progressive overload stimulates muscle adaptation and hypertrophy, leading to gains in muscle strength over time. By gradually increasing the resistance, PNF helps breast cancer patients rebuild strength safely and effectively without overexertion or risk of injury.

Hence, this study explores the potential benefits of incorporating PNF exercises into Cancer Rehabilitation programs, particularly in enhancing motor function (muscle strength), and functional abilities involving their activities of daily living in these population

2. METHODOLOGY

The research was structured as an experimental randomized controlled trial. Sample size 66, both male and female in the age group of 40-60 years was included in the study. The subjects were randomly allocated into two groups. The Ethical approval was obtained from Institutional. Ethics Committee for research. The informed consent was taken from all the subjects who participated in the study. Subjects were screened from the Krishna Hospital Oncology Chemotherapy department as per as the inclusion criteria. All patients followed up with the therapist regularly thrice a week for 40 mints session Out of 66 healthy individuals 61 successfully completed the treatment intervention of 4 weeks. Among five, two Subjects from Group B discontinued the treatment intervention due to the complaints of heaviness and pain in the same extremity, one subject due to development of recurrence of the disease, while other one subject due to transportation issue and among two from Group A, one subject discontinued due to their transportation issue and time of conflict while other one excluded due to their change in treatment plan. Group A: 31 subjects (PNF Training) and Group B; 29 subjects (Conventional Physiotherapy). Each for a duration of 4 weeks. Each participant underwent a clinical evaluation on 1Repetition Maximum (RM) and Lawton Instrumental Activities of Daily Living (L-IADLs) at 1st day and the last day of 4th week.

3. OUTCOME MEASURES

1. **The one-repetition maximum (1-RM) tests** – It serve as a pivotal measure in assessing an individual's maximal lifting capacity, representing the utmost weight they can lift in a single repetition. With reliability and validity ranging from 0.64 to 0.99, they offer a robust method for gauging strength levels. Utilizing Epley's Equation to determine the 1 RM, the formula incorporates the weight lifted, repetitions performed, and a conversion factor. This equation, 1RM = (Weight Lifted Repetitions 0.0333) + Weight lifted, enables precise calculation, enhancing the accuracy of strength assessments.
2. **The Lawton-Brody Instrumental Activities of Daily Living Scale (I.A.D.L.) -** It comprises eight components designed to assess the performance of basic activities of daily living (ADLs) in subjects. With a reliability and validity rating of 0.85, this scale offers a robust framework for evaluating functional independence. Interpretation of the scale is based on scoring ranges: lower scores (0-5) indicate maximum dependency and low function, while higher scores (5-8) signify minimum dependency and high function.

INCLUSION CRITERIA:

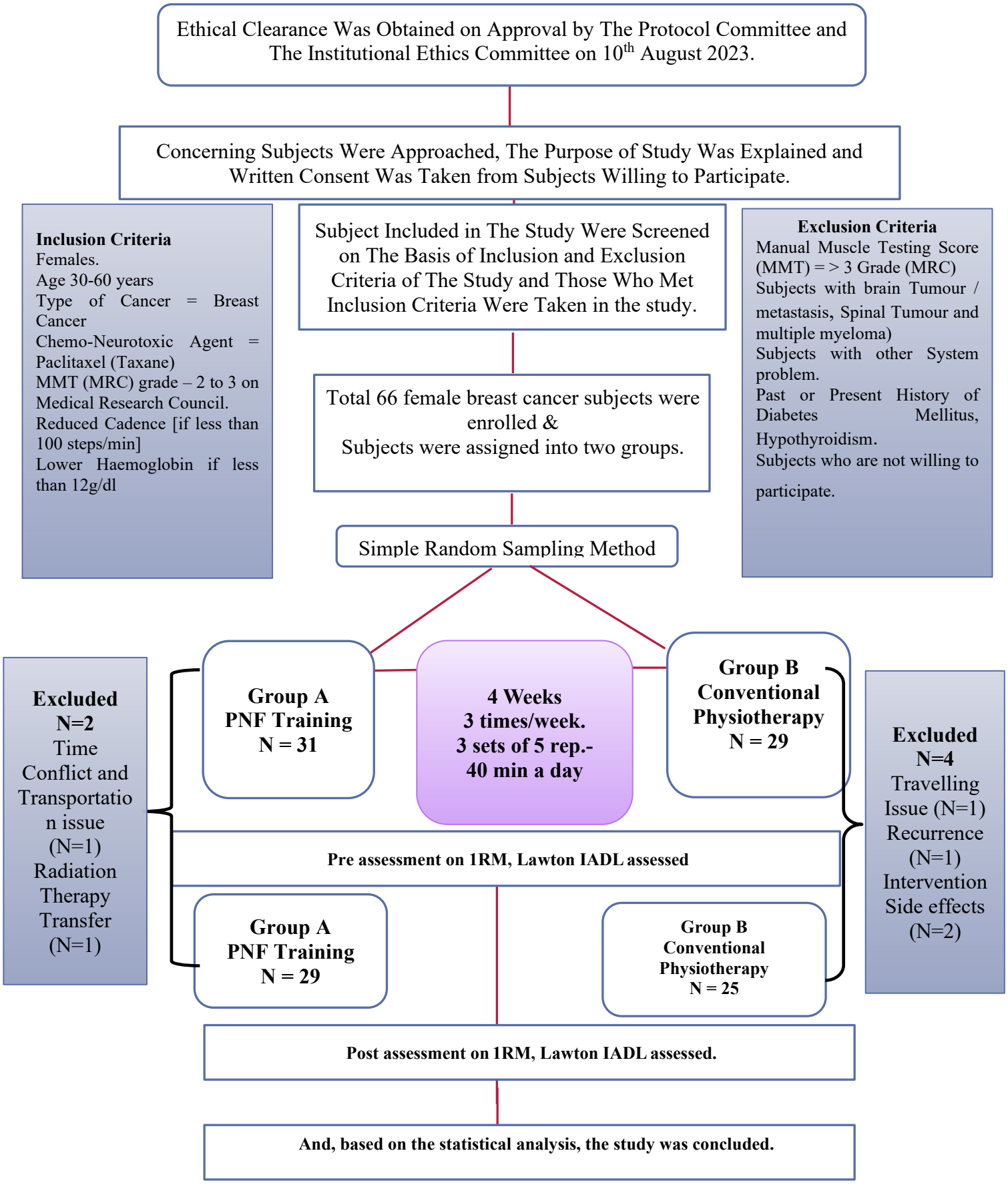
1. Females.
2. Age 30-60 years
3. Type of Cancer = Breast Cancer
4. Chemo-Neurotoxic Agent = Paclitaxel (Taxane)
5. MMT (MRC) grade – 2 to 3 on Medical Research Council.
6. Reduced Cadence [if less than 100 steps/min]
7. Lower Haemoglobin if less than 12g/dl
8. Subjects who are willing to participate.

EXCLUSION CRITERIA:

1. Age Group = >60 Years.
2. Manual Muscle Testing Score (MMT) = > 3 Grade (MRC)
3. Subjects with brain Tumour / metastasis, Spinal Tumour and multiple myeloma)
4. Subjects with other System problem (Vision Problem, Auditory Sense Disorder, Severe dyspnoea, Chest Pain, Peripheral Vascular Disease, Osteoporosis, Joint Arthritis, Recent Unhealed lower limb Fracture / deformity, Cervical or lumbar spine stenosis)
5. Past or Present History of Diabetes Mellitus, Hypothyroidism.
6. Subjects who are not willing to participate.
7.

4. STUDY PROCEDURE

All 60 subjects were explained in detail about the study procedure. The informed Consent was taken from each patient participating in study. Each subject was assessed using 1 RM and LIADLs to determine strength and activities of daily living. All patients followed up with the therapist regularly thrice a week for 40 mints session each for a duration of 4 weeks. Each subject underwent a clinical evaluation on 1 RM [Bicep and Quadricep] and LIADLs at pre and post intervention.


Ethical Clearance Was Obtained on Approval by The Protocol Committee and The Institutional Ethics Committee on 10th August 2023.
Concerning Subjects Were Approached, The Purpose of Study Was Explained and Written Consent Was Taken from Subjects Willing to Participate.
Inclusion Criteria
Females.
Age 30-60 years
Type of Cancer = Breast Cancer
Chemo-Neurotoxic Agent = Paclitaxel (Taxane)
MMT (MRC) grade – 2 to 3 on Medical Research Council.
Reduced Cadence [if less than 100 steps/min]
Lower Haemoglobin if less than 12g/dl
Subject Included in The Study Were Screened on The Basis of Inclusion and Exclusion Criteria of The Study and Those Who Met Inclusion Criteria Were Taken in the study.
Exclusion Criteria
Manual Muscle Testing Score (MMT) = > 3 Grade (MRC)
Subjects with brain Tumour / metastasis, Spinal Tumour and multiple myeloma)
Subjects with other System problem.
Past or Present History of Diabetes Mellitus, Hypothyroidism.
Subjects who are not willing to participate.
Total 66 female breast cancer subjects were enrolled &
Subjects were assigned into two groups.
Simple Random Sampling Method
Excluded N=2
Time Conflict and Transportation issue (N=1)
Radiation Therapy Transfer (N=1)
Group A PNF Training N = 31
4 Weeks 3 times/week. 3 sets of 5 rep.- 40 min a day
Group B Conventional Physiotherapy N = 29
Excluded N=4
Travelling Issue (N=1)
Recurrence (N=1)
Intervention Side effects (N=2)
Pre assessment on 1RM, Lawton IADL assessed
Group A PNF Training N = 29
Group B Conventional Physiotherapy N = 25
Post assessment on 1RM, Lawton IADL assessed.
And, based on the statistical analysis, the study was concluded.

5. INTERVENTION

Table 1 – Interventions of The Groups.

Group A **Proprioceptive Neuromuscular Facilitation**	**Group B** **Conventional Physiotherapy**
3 sets of 5 repetitions – 40 minutes – 3 times per week	
Week 1 ✓ Proprioceptive Neuromuscular Facilitation. ✓ Technique – Rhythmic Stabilization ✓ Pattern – D1 and D2 Flexion and Extension ✓ [with 10 seconds hold each]	**Week 1** ✓ Shoulder Flexion, Extension, Abduction, Adduction with Wand ✓ Hip Flexion and Extension ✓ Hip Abduction and Adduction ✓ [with 10 seconds hold each]
Week 2 ✓ Resistance Strength Training in diagonal pattern.	**Week 2** ✓ Resistance Strength Training
Week 3 ✓ Progression of Resistance Strength Training in diagonal pattern.	**Week 3** ✓ Progression of Resistance Strength Training
Week 4 ✓ ADL's Specific Training	**Week 4** ✓ ADL's Specific Training

6. STATASTICAL ANALYSIS

GraphPad Software, San Diego, California's InStat version 3.06 was used to do the statistical analysis. The information was displayed as mean plus standard deviation (SD). The pre- and post-values of the 1RM score and LIADLs within group A were analysed using the paired t-test, and the outcomes between two separate groups were compared using the unpaired t-test. that is, Groups A and B.

7. RESULT

Table 2– Baseline characteristics of patients in both groups.

Age	**Group A**	**Group B**	**Total**	**Percentage**
30-40	17	07	24	39.34%
41-50	09	14	23	37.70%
51-60	05	09	14	22.95%
MRC - MMT Grade	**Group A**	**Group B**		
Grade 2	07	04	11	18.03%
Grade 2+	14	11	25	40.98%
Grade 3-	06	09	15	24.59%
Grade 3	04	06	10	16.39%

CADENCE	**Group A**	**Group B**
<100	29	32
%Percentage Cadence	47.54%	52.45%
Haemoglobin (Hb) Level	**Group A**	**Group B**
<12g/dl	27	34
% Percentage Hb Level	44.26%	55.73%

Table 3 - Comparison of Pre and Post Values of Outcome Measures Using Paired t Test Within Group A Presenting Proprioceptive Neuromuscular Facilitation Intervention on Paclitaxel Chemotherapy Induced Motor Dysfunction and Activities of Daily Living in Breast Cancer Survivors.

Parameters	**Outcome Measure**	**Values of Group A**		**t - value**	**p-value**
		Pre	**Post**		
		Mean ±SD	**Mean±SD**		
Strength	1RM Bicep	18.3±3.2	25.7±3.6	26.13	<0.0001
	1RM Quads	23.9±2.3	37.4±3.1	29.40	<0.0001
Activities of Daily Living	L- IADL Score	8.66±1.88	12.54±2.08	30.57	<0.0001

According to Table 3- the findings from this study examining the efficacy of Proprioceptive Neuromuscular Facilitation (PNF) intervention on paclitaxel chemotherapy induced motor dysfunction and activities of daily living in breast cancer survivors within Group A have demonstrated significant improvements across multiple outcome measures. The comparison of pre- and post-intervention values using paired t-tests within Group A revealed remarkable enhancements in motor function, with significant mean differences of 7.4 in bicep strength and 13.5 in quadricep strength (as assessed by 1RM), with a p-value of <0.0001. Additionally, Group A showed significant improvements in their activities of daily living, with a mean difference of 3.88 and a p-value of <0.0001. **These findings underscore the extremely significant effectiveness of PNF intervention in improving paclitaxel chemotherapy induced motor dysfunction and activities of daily living in breast cancer survivors.**

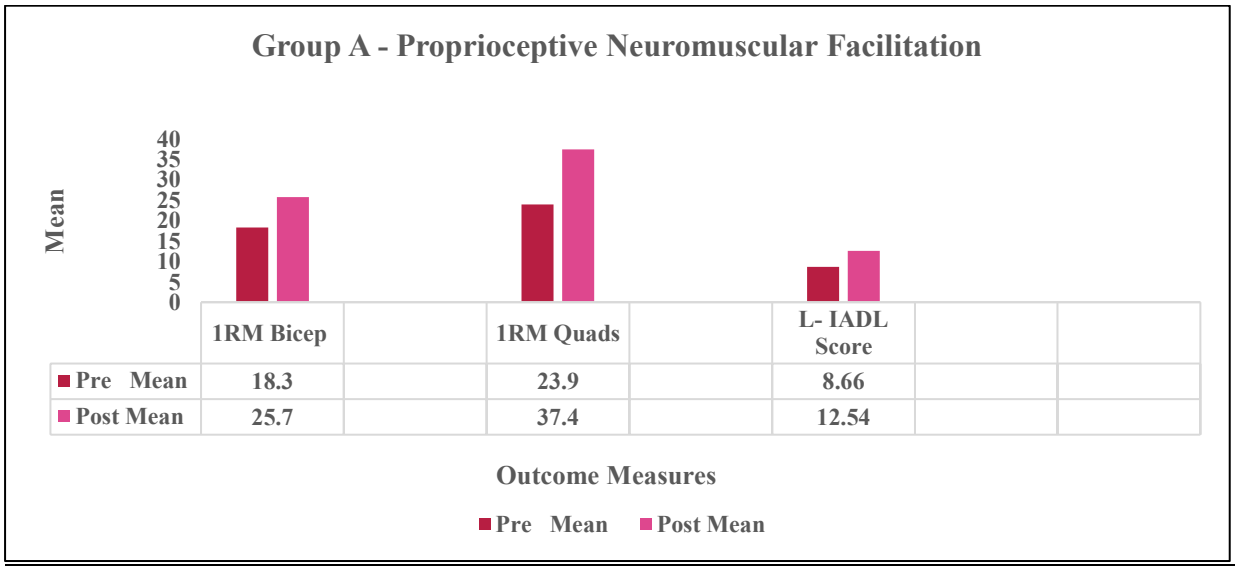


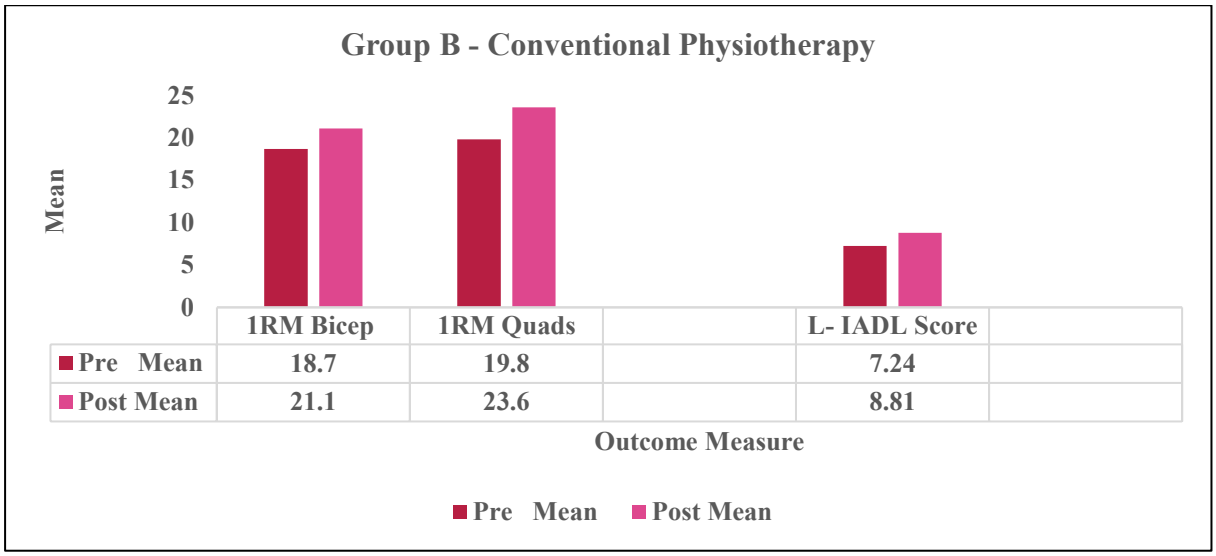
Table 4 - Comparison of Pre and Post Values of Outcome Measures Using Paired t Test Within Group B Presenting Proprioceptive Neuromuscular Facilitation Intervention on Paclitaxel Chemotherapy Induced Motor Dysfunction and Activities of Daily Living in Breast Cancer Survivors.

Parameters	Outcome Measure	Values of Group B		t - value	p-value
		Pre	Post		
		Mean ±SD	Mean±SD		
Strength	1RM Bicep	18.7±3.8	21.1±2.9	24.23	0.0103
	1RM Quads	19.8±1.9	23.6±2.3	25.71	0.0321
Activities of Daily Living	L- IADL Score	7.24±1.38	8.81±1.94	3.40	0.0011

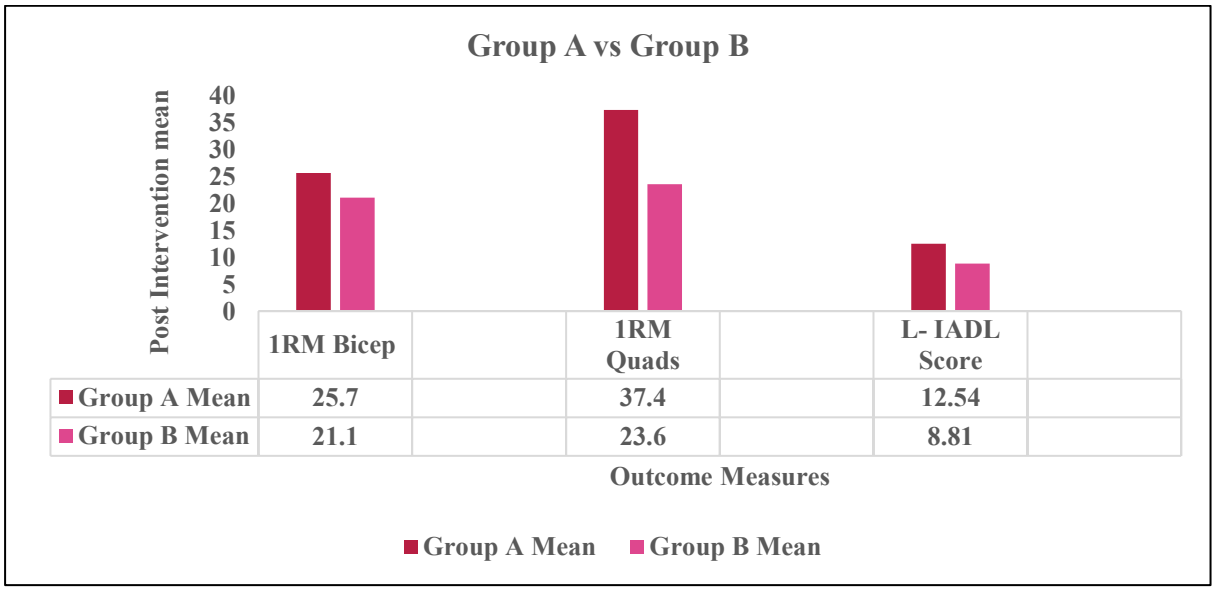
According to Table 4 - the findings from this study examining the efficacy of Proprioceptive Neuromuscular Facilitation (PNF) intervention on paclitaxel chemotherapy induced motor dysfunction and activities of daily living in breast cancer survivors within Group B reveals noteworthy insights into the effectiveness of this intervention approach. The comparison of pre- and post-intervention values using paired t-tests within Group B revealed remarkable enhancements in motor function, with significant mean differences of 2.4 in bicep and 3.9 in quadricep strength (as assessed by 1RM), with a p-value of 0.0103 and 0.0321 respectively. Also, Group B showed their activities of daily living, with a mean difference of 1.63 with p value 0.0011. These findings underscore **the considerable effectiveness of conventional physiotherapy intervention in improving** paclitaxel chemotherapy induced motor dysfunction and activities of daily living in breast cancer survivors.

Table 5– Comparison of Post Values of Outcome Measures Using Unpaired t Test Between Group A and B Intervention on Paclitaxel Chemotherapy Induced Motor Dysfunction and Activities of Daily Living in Breast Cancer Survivors.

Parameters	Outcome Measure	Post Intervention Values		t - value	p-value
		Group A	Group B		
		Mean±SD	Mean±SD		
Strength	1RM Bicep	25.7±3.6	21.1±2.9	11.63	<0.0001*
	1RM Quads	37.4±3.1	23.6±2.3	16.84	<0.0001*
Activities of Daily Living	L- IADL Score	12.54±2.08	8.81±1.94	10.63	<0.0001*



✓ **According to table above -** The comparison of post-intervention values between Group A and Group B interventions on paclitaxel chemotherapy induced motor dysfunction and activities of daily living in breast cancer survivors **r**eveals significant differences across multiple outcome measures, highlighting distinct effects of the interventions. **Group A demonstrates a significantly higher mean 1RM score (25.7 ± 3.6) Bicep (37.4±3.1) Quadricep and compared to Group B (21.1 ± 2.9), with a substantial t-value of 11.63, 16.84 ($p < 0.0001$).** This indicates superior strength and muscle performance outcomes for participants in Group A compared to those in Group B. Also, in terms of activities of daily living (ADLs**), Group A exhibits a significantly higher mean L-IADL's score (12.54 ± 2.08) compared to Group B (8.81 ± 1.94),** with a considerable t-value of 10.63 ($p < 0.0001$), indicating greater improvements in functional independence for participants in Group A compared to Group B.



8. DISCUSSION

To the best of these knowledge, randomized clinical trials investigating the use of Proprioceptive Neuromuscular Facilitation (PNF) for treating sensorimotor dysfunction in breast cancer patients have not been documented in the literature, Furthermore, there has lack of literatures regarding the study on the application of outcome measures such as the 1Repetition Maximum, and the Lawton Instrumental Activity of Daily Living, which focus on motor function such as strength, and ADLs in patients with breast cancer patients. While research supports the benefits of PNF and resistance training for neurological conditions, studies specifically focusing on paclitaxel-induced weakness with this combined approach are limited.

Therefore, the study titled effectiveness of proprioceptive neuromuscular facilitation technique on paclitaxel chemotherapy induced motor dysfunction and activities of daily living in breast cancer survivors. - a randomized controlled trial. was conducted with an objective to find out the effectiveness of proprioceptive neuromuscular facilitation technique on paclitaxel chemotherapy induced motor dysfunction in breast cancer survivors by one-repetition maximum. And to find out the Effectiveness of Proprioceptive Neuromuscular Facilitation Technique on Paclitaxel Chemotherapy Induced ADLs in Breast Cancer Survivors by using Lawton Instrumental ADL Scale.

In this study, the 30-40 age group predominates, comprising 39.34% of the population experiencing motor dysfunction due to paclitaxel chemotherapy, indicating a heightened susceptibility among younger individuals, particularly those in their 30s and early 40s. Potential factors contributing to this include younger patients undergoing more aggressive treatments, possessing higher metabolic rates, and being more attuned to and likely to report side effects due to their increased activity levels. However, it's noteworthy that broader research by HANNAH C. TIMMINS et al. (2021) and MEGHNA S. TRIVEDI et al. (2023) suggests the mean age for developing motor deficits from paclitaxel chemotherapy is over 50 years old, indicating a divergence in findings regarding age-related susceptibility. Further investigation is warranted to reconcile these discrepancies and better grasp the age-related risks of motor dysfunction in paclitaxel-treated patients.

Additionally, the study highlights Grade 2+ on the Manual Muscle Testing (MMT) scale as predominant, encompassing 40.98% of participants, indicative of moderate muscle impairment among the assessed individuals.

Understanding the interrelationship between cadence and haemoglobin levels in these groups is crucial for effective clinical management and supportive care during chemotherapy. This study underscores a correlated pattern: a higher prevalence of reduced cadence, ranging from 47.54% to 52.45%, potentially influenced by varying physical activity levels, severity of chemotherapy side effects, or underlying health conditions affecting mobility. Correspondingly, the study reveals a heightened prevalence of anaemia or chemotherapy-induced reductions in red blood cell production, ranging from 44.26% to 55.73%. These findings underscore the interconnected nature of mobility limitations and physiological impacts during chemotherapy, highlighting the necessity for tailored interventions addressing both aspects to enhance patient outcomes effectively.

The proposed intervention strategy of PNF with rhythmic stabilization, diagonal resistance training with weight progression, holds promise for improving strength in biceps and quadriceps of patients experiencing paclitaxel-induced motor dysfunction as measured by 1RM, exhibited a substantial improvement in this study (25.7 ± 3.6), $p<0.0001$). Paclitaxel disrupts microtubule formation, essential for proper nerve function. This leads to peripheral neuropathy [Damage to peripheral nerves supplying muscles like biceps and quadriceps, causing weakness and incoordination] and proprioceptive Deficits [Altered sensation of limb position and movement, hindering motor control] Rhythmic stabilization with PNF techniques utilizes holds and manual contacts to stimulate proprioceptive and tactile receptors. This enhanced sensory input improves the nervous system's ability to recruit and coordinate muscle activity.

Studies have shown PNF to be effective in improving proprioception and motor function in various neurological conditions such as peripheral neuropathy, diabetic neuropathy [26,29]. Diagonal PNF patterns engage multiple muscle groups (agonists and antagonists) that work together during functional movements. This co-activation can help overcome the isolation weakness caused by paclitaxel and promote better motor recruitment patterns. Research suggests diagonal PNF exercises may be more effective for improving functional activities compared to traditional isolation exercises. Resistance training with progressive weight increases challenges the weakened muscles, leading to adaptations like increased muscle fiber size and improved neuromuscular efficiency. This translates to greater strength in biceps and quadriceps, making daily activities more manageable. Studies have shown resistance training to be a cornerstone of rehabilitation for paclitaxel-induced neuropathy, with progressive overload being crucial for strength gains.

The combination of PNF with rhythmic stabilization, diagonal resistance training, and weight progression offers a comprehensive approach .PNF enhances sensory input, leading to better muscle recruitment and coordination, overcoming the deficits caused by paclitaxel. Diagonal resistance training with weight progression specifically strengthens weakened biceps and quadriceps, improving their force generation capacity.

The current study is supported by research by WANG, L., et al. (2013), CHO, D. H., et al. (2014), ZIEGLER, A. J., et al. (2018) DR. RITU PARNA MOHANTY et al. (2022) All these studies support the potential benefits of exercise interventions for improving motor function in individuals with neurological conditions. Study 1 and 2 provide evidence for PNF, especially diagonal patterns, as a promising approach to enhance proprioception, motor function, and functional abilities .Study 3 strengthens the rationale for incorporating resistance training to address weakness associated with paclitaxel-induced neuropathy .while study 4 concluded that, the integration of PNF approaches with progressive resistance training requires synchronisation between the brain system and muscles leading to enhanced motor control, coordination, and efficiency of movements [26,27,28,29].

In this study, the improvement in the ADLs have seen by L-IADL (12.54 ± 2.08), $p<0.0001$ which is attributed by the technique of PNF. Paclitaxel disrupts microtubule formation in nerves, hindering proper sensory and motor signals. PNF techniques use specific hand placements and rhythmic holds to stimulate proprioceptive and tactile receptors in muscles

and joints. This improved sensory input: Increases awareness of limb position and movement in space (proprioception). Enhances communication between the nervous system and muscles Traditional therapeutic exercises often focus on isolated muscle groups. PNF training for ADL improvement incorporates functional movement patterns used in daily activities like reaching, grasping, transferring objects, or dressing. This targeted approach allows Improved neuromuscular control during those specific tasks. Increased efficiency and reduced effort required for daily activities. By practicing these diagonal patterns, patients felt enhanced coordination between different muscle groups involved in ADLs. which improved their overall functional movement patterns used in daily activities.

Similarly, for the conventional Physiotherapy group, there was a considerable significant improvement in muscle strength assessed by 1RM (21.1±2.9) p = 0.0103 for bicep as well as (23.6±2.3) p=0.0321for quadricep and ADLs assessed by L-IADL's (8.81±1.94) p = 0.0011 following conventional Physiotherapy methods which rely on external appliances like mobility wands, weight cuffs and its application in non-diagonal PNF pattern. Conventional Physiotherapy methods included with mobility exercises in the first week of the intervention helps to loosen up the tight muscles, increases vascularization and induces mitochondrial activity, helps to reduces oxidative stress and inflammation from nerve structures. By enhancing blood flow, oxygen and nutrient to the nervous system, it supports nerve structure and nerve function. Also, resistance training started in second week which is been progressed up to three weeks helps to prevent muscle loss. It is also found to be improving intermuscular and intramuscular synchronization through neural control which increases the muscles capacity to hold contractions over time contributing to increase muscle strength and endurance [30]. The present study is supported by research conducted by SHELLY DHAWAN AND NIKITA H. SETH, which examined the effects of muscular strengthening and balancing activities on quality of life among Cancer patients and chemotherapy-induced peripheral neuropathic pain, respectively [31].

ADL improvement was improved in this study by compensating reduction in nerve damaged with increased muscle strength which is also been seen in the study done by Giorgio Orlando showed positive effect of resistance and aerobic training in people with diabetic peripheral neuropathy [32].

As seen in the results, there was an extremely significant improvement in the values of 1RM, and L-IADL for the PNF group than Conventional Physiotherapy group after intervention. The study's results supported the null hypothesis, which posited the positive effect of proprioceptive neuromuscular facilitation on paclitaxel chemotherapy induced motor dysfunction and activities of daily living in breast cancer survivors.

9. CONCLUSION

The present study concludes that both PNF technique and conventional Physiotherapy were effective in addressing paclitaxel chemotherapy induced motor dysfunction and activities of daily living in breast cancer survivors. The findings of the study demonstrated significant improvements in strength, and hence, activities of daily living (ADLs) with both techniques. However, group A, which received PNF training, exhibited more pronounced improvements in enhancing strength and ADLs, thereby indicating greater functional independence compared to group B receiving conventional Physiotherapy.

10. ABBREVATIONS

PNF – PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION

ADL- ACTIVITIES OF DAILY LIVING

1RM – ONE REPETITION MAXIMUM

L-IADLS – LAWTON INSTRUMENTAL ACTIVITIES OF DAILY LIVINGS

MRC – MEDICAL RESEARCH COUNCIL

11. ACKNOWLEDGEMENT

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13. CONFLICT OF INTEREST

The Authors declares no conflict of interest.

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