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"EFFECTIVENESS OF PNF AND PROGRESSIVE RESISTANCE EXERCISE ON STRENGTHENING AND BALANCE IN PATIENTS WITH DIABETIC NEUROPATHY TYPE 2"

ABSTRACT

Background: Diabetic neuropathy (DN) is a common complication of Type 2 diabetes mellitus, affecting nearly 50% of patients and leading to muscle weakness, balance impairments, and an increased risk of falls. Exercise-based interventions, particularly Proprioceptive Neuromuscular Facilitation (PNF) and Progressive Resistance Exercise (PRE), have been shown to improve neuromuscular function, but their comparative effectiveness in DN rehabilitation remains underexplored. **Objective:** This study aimed to evaluate the impact of PNF and PRE on muscle strength and balance in patients with Type 2 DN, as well as to determine whether a combined intervention yields superior outcomes. **Methods:** A quasi-experimental pre-test and post-test study was conducted at People's Hospital, Bhopal, involving 35 participants aged 40-70 years with clinically diagnosed DN. Participants were assigned to three groups: PNF-only, PRE-only, and a combined PNF+PRE group. Lower limb strength was measured using a handheld dynamometer, while balance stability was assessed via the Berg Balance Scale. Exercises were conducted three times per week for 12 weeks, with intensity progressively increased. Data were analyzed using paired t-tests and one-way ANOVA. **Results:** Both PNF and PRE interventions led to significant improvements ($p < 0.001$) in strength and balance. The PRE group showed greater gains in muscle strength, whereas the PNF group demonstrated superior balance improvements. The combined PNF+PRE group exhibited the most substantial overall improvements, though intergroup differences were not statistically significant in post hoc analysis. **Conclusion:** PNF and PRE are both effective rehabilitation strategies for DN patients, with PRE being optimal for strength enhancement and PNF excelling in balance training. A combined approach may offer comprehensive benefits, supporting the integration of both modalities in physiotherapy protocols for improved mobility, fall prevention, and quality of life.

***Keywords*:** Diabetic Neuropathy, Proprioceptive Neuromuscular Facilitation, Progressive Resistance Exercise, Balance Training, Strength Rehabilitation

1. INTRODUCTION

Diabetic neuropathy, a common complication of Type 2 diabetes mellitus (T2DM), affects nearly 50% of diabetic patients, significantly impairing balance, muscle strength, and mobility. Peripheral neuropathy, the most prevalent form, leads to progressive nerve damage, resulting in sensory loss, motor dysfunction, and increased fall risk due to instability. The condition arises from chronic hyperglycemia, oxidative stress, and vascular damage, which compromise nerve function and neuromuscular control.

Exercise-based physiotherapy interventions have been shown to mitigate these deficits by improving strength, balance, and proprioception. Among various techniques, Proprioceptive Neuromuscular Facilitation (PNF) and Progressive Resistance Exercise (PRE) have demonstrated promising outcomes in neuromuscular rehabilitation. PNF enhances neuromuscular coordination and proprioception through dynamic stretching and contraction-relaxation exercises, while PRE focuses on progressively increasing resistance to improve muscle strength and endurance.

Studies suggest that combining PNF and PRE may provide synergistic benefits, addressing both strength and balance deficits in diabetic neuropathy patients. While PNF improves proprioception and motor control, PRE enhances muscle mass and function, both of which are crucial for stability

and fall prevention. Despite growing evidence supporting exercise interventions, limited research has explored the comparative and combined effectiveness of PNF and PRE in diabetic neuropathy rehabilitation.

This study aims to investigate the impact of PNF and PRE on balance, strength, and functional independence in diabetic neuropathy patients. By evaluating their relative and combined effects, this research seeks to inform evidence-based physiotherapy protocols for enhancing mobility, reducing fall risk, and improving quality of life in individuals with diabetic neuropathy.

2. OBJECTIVES

- To evaluate whether Proprioceptive Neuromuscular Facilitation (PNF) exercises significantly improve lower limb strength in patients with Type 2 diabetic neuropathy.
- To determine the effect of PNF exercises on balance stability in patients with Type 2 diabetic neuropathy.
- To assess whether Progressive Resistance Exercise (PRE) significantly enhances muscle strength in patients with Type 2 diabetic neuropathy compared to a non- exercise control group.
- To compare the effectiveness of PNF and PRE on balance improvement in patients with Type 2 diabetic neuropathy.
- To investigate if a combined intervention of PNF and PRE results in significantly greater improvements in strength and balance than either intervention alone in patients with Type 2 diabetic neuropathy.

3. HYPOTHESIS

3.1 Null Hypothesis (H0):

There will be no significant difference in strengthening and balance outcomes between patients with Type 2 Diabetic Neuropathy who participate in Proprioceptive Neuromuscular Facilitation (PNF) and Progressive Resistance Exercise (PRE) compared to those who do not engage in these specific exercise interventions.

3.2 Alternate Hypothesis (H1):

Patients with Type 2 Diabetic Neuropathy who participate in Proprioceptive Neuromuscular Facilitation (PNF) and Progressive Resistance Exercise (PRE) will demonstrate a significant improvement in strengthening and balance outcomes compared to those who do not engage in these specific exercise interventions.

4. METHODOLOGY

This study follows a quasi-experimental pre-test and post-test design to evaluate the effects of Proprioceptive Neuromuscular Facilitation (PNF) and Progressive Resistance Exercise (PRE) on muscle strength and balance in patients with Type 2 diabetic neuropathy. The research will be conducted at People's Hospital, Bhopal, Bhanpur, where patients will be recruited from outpatient clinics and diabetic care centers. A purposive sampling method will be employed, initially selecting 40 patients to account for a 10-15% dropout rate, with a final sample size of 35 participants. The study duration is planned for 3 to 4 months.

The study examines two independent variables: the type of exercise intervention (PNF, PRE, or a combined approach). The dependent variables include lower limb muscle strength and balance stability, which will be measured before and after the intervention. Participants will be included if they are aged 40 to 70 years, have a clinical diagnosis of Type 2 diabetic neuropathy, and experience balance impairments or reduced lower limb strength. They must also be able to follow exercise instructions and willing to provide informed consent. Exclusion criteria include severe cardiovascular complications, neurological disorders such as Parkinson's disease, recent lower limb

fractures, or participation in other physical therapy programs that could affect muscle strength or balance.

For data collection, a handheld dynamometer will be used to measure muscle strength, while the Berg Balance Scale will assess stability and balance metrics. Participants will be randomly assigned into three groups: Group 1 will perform PNF exercises, focusing on stretching and neuromuscular facilitation techniques. Group 2 will engage in PRE exercises, incorporating progressive resistance exercises using resistance bands and free weights. Group 3 will follow a combined PNF+PRE program, integrating both approaches to enhance strength and balance simultaneously. The exercise sessions will take place three times per week for 12 weeks, totaling 36 sessions, with a gradual increase in exercise intensity every two weeks.

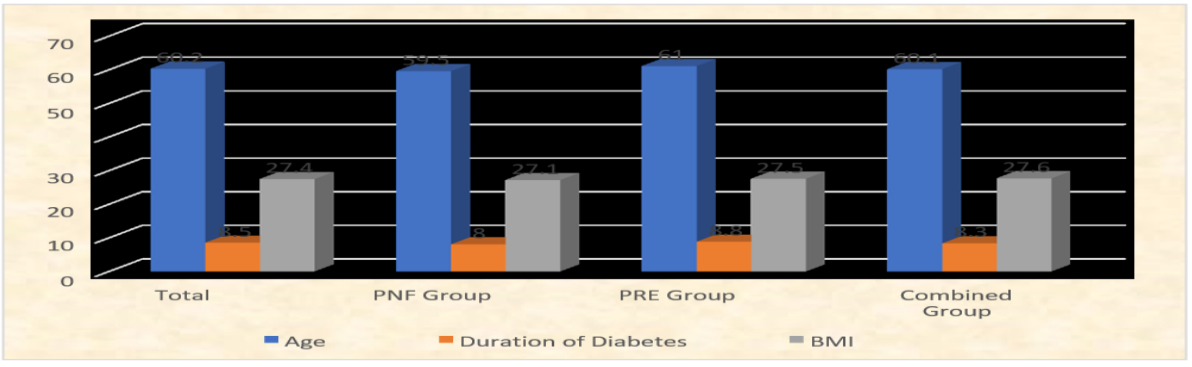
The study will assess muscle strength using hand-held dynamometry and manual muscle testing (MMT), while functional strength tests, such as the 30-second sit-to-stand test and single-leg stance test, will evaluate endurance and stability. The intervention will include PNF techniques, such as diagonal movement patterns, rhythmic stabilization, and the hold-relax method, designed to improve neuromuscular coordination and proprioceptive feedback. The PRE exercises will include squats, leg press, step-ups, and ankle dorsiflexion/plantar flexion movements with resistance bands, targeting key muscle groups to enhance functional strength.

After 12 weeks, a post-test assessment will be conducted using the same evaluation methods to measure changes in muscle strength and balance stability. The collected data will be analyzed using SPSS software, applying paired t-tests to compare pre- and post-test scores within each group. A one-way ANOVA will be performed to identify differences among the three intervention groups, followed by post hoc analysis (Tukey's HSD) to determine specific group differences. A p-value of less than 0.05 will be considered statistically significant.

5. RESUL AND OBSERVATION

Table 1: Demographic Characteristics of Participants

Demographic Variable	Total (N=35)	PNF Group (n=12)	PRE Group (n=12)	Combined Group (n=11)
Age (years)	60.2 ± 8.1	59.5 ± 7.9	61.0 ± 8.3	60.1 ± 8.5
Gender (Male/Female)	15/20	5/7	6/6	4/7
Duration of Diabetes (years)	8.5 ± 3.4	8.0 ± 2.9	8.8 ± 3.7	8.3 ± 3.5
BMI (kg/m²)	27.4 ± 3.2	27.1 ± 3.1	27.5 ± 3.4	27.6 ± 3.2

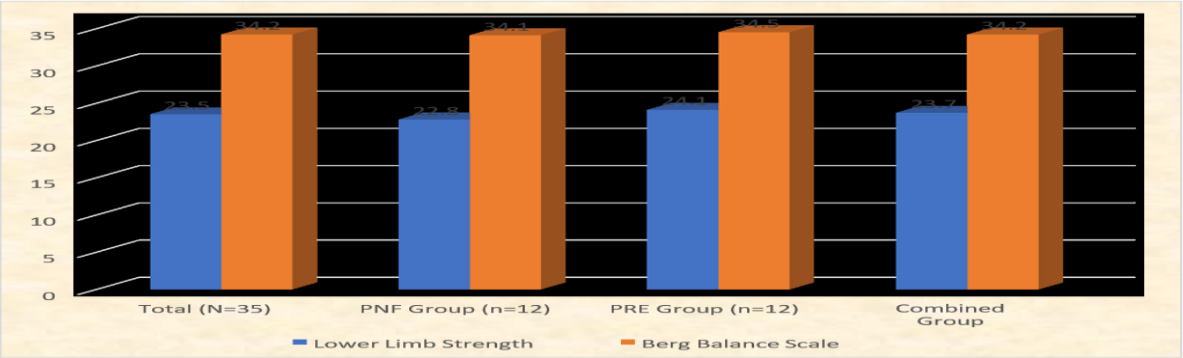


Graph 1: Demographic Characteristics of Participants

Interpretation: This table provides a descriptive summary of participant demographics across the three study groups: PNF (Proprioceptive Neuromuscular Facilitation), PRE (Progressive Resistance Exercise), and Combined. The average age of participants was approximately 60 years, and the groups were relatively well- balanced in terms of gender and duration of diabetes. These similarities in baseline demographics indicate that the groups were comparable before the intervention, reducing the likelihood that age, duration of diabetes, or BMI influenced the outcomes. This balance across demographics supports the internal validity of the study.

Table 2: Baseline Measurements of Strength and Balance

Measurement	Total (N=35)	PNF Group (n=12)	PRE Group (n=12)	Combined Group (n=11)
Lower Limb Strength (kg)	23.5 ± 5.4	22.8 ± 5.0	24.1 ± 5.7	23.7 ± 5.3
Berg Balance Scale Score	34.2 ± 6.1	34.1 ± 6.3	34.5 ± 5.8	34.2 ± 6.2

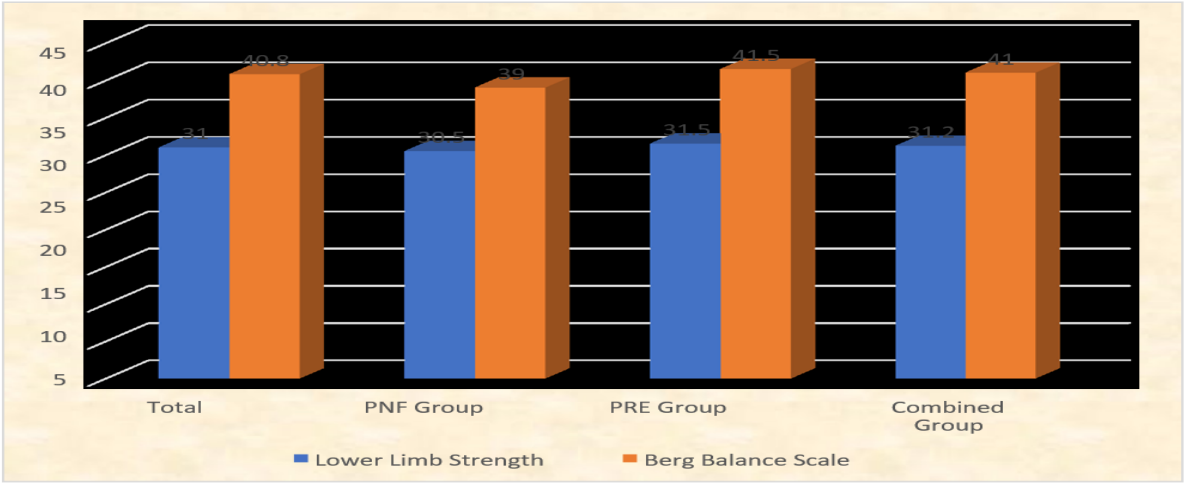


Graph 2 : Baseline Measurements of Strength and Balance

Interpretation: At baseline, lower limb strength and balance scores (using the Berg Balance Scale) were similar across the PNF, PRE, and Combined groups, with no statistically significant differences. This similarity suggests that each group began at a comparable functional level, which is essential for a fair comparison of post- intervention outcomes. It also implies that any differences observed after the intervention are likely attributable to the specific type of exercise regimen each group received.

Table 3: Post-Intervention Measurements of Strength and Balance

Measurement	Total (N=35)	PNF Group (n=12)	PRE Group (n=12)	Combined Group (n=11)
Lower Limb Strength (kg)	31.0 ± 6.3	30.5 ± 6.0	31.5 ± 6.5	31.2 ± 6.4
Berg Balance Scale Score	40.8 ± 5.4	39.0 ± 5.1	41.5 ± 5.6	41.0 ± 5.8



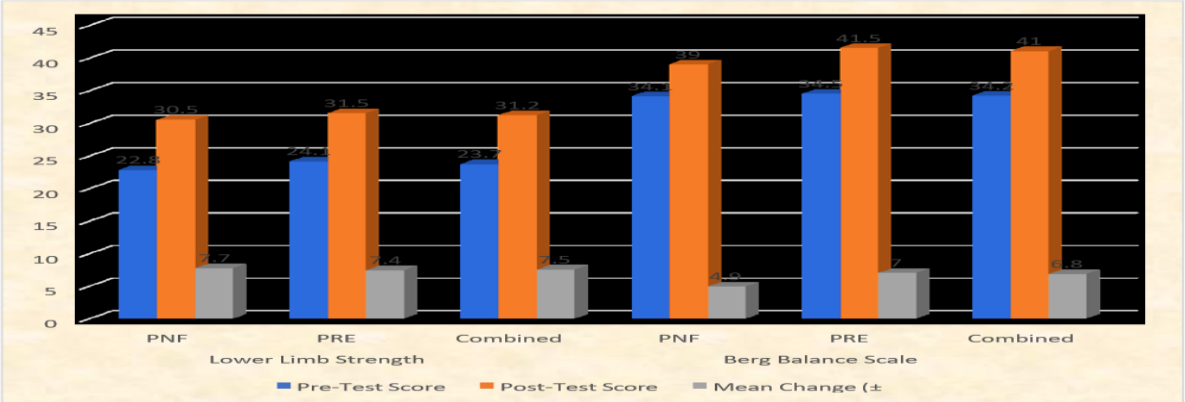
Graph 3 : Post-Intervention Measurements of Strength and Balance

Interpretation: The post-intervention data show marked improvements in both lower limb strength and balance across all three groups. Notably, each group exhibited a mean increase in strength and balance scores, suggesting that both PNF and PRE, either alone or combined, positively impacted these outcomes. The Combined group demonstrated the highest average scores, suggesting that integrating both PNF and PRE might be slightly more effective. These improvements align with the

study's aim to evaluate the effectiveness of these interventions in patients with diabetic neuropathy.

Table 4: Changes in Strength and Balance Scores Within Groups

Measurement	Group	Pre-Test Score	Post- Test Score	Mean Change (± SD)	p-value (Paired t- test)
Lower Limb Strength (kg)	PNF	22.8 ± 5.0	30.5 ±6.0	7.7 ± 1.1	< 0.001
	PRE	24.1 ±5.7	31.5 ±6.5	7.4 ± 1.2	< 0.001
	Combined	23.7 ±5.3	31.2 ±6.4	7.5 ± 1.0	< 0.001
Berg Balance Scale Score	PNF	34.1 ±6.3	39.0 ±5.1	4.9 ± 0.9	< 0.001
	PRE	34.5 ±5.8	41.5 ±5.6	7.0 ± 1.1	< 0.001
	Combined	34.2 ±6.2	41.0 ±5.8	6.8 ± 1.0	< 0.001



Graph 4 : Changes in Strength and Balance Scores within Groups

Interpretation: This table compares pre- and post-test scores within each group using paired t-tests. All groups demonstrated statistically significant improvements ($p < 0.001$) in both strength and balance scores. The mean increase in lower limb strength was similar across groups, with the combined group showing the most significant gains, followed by the PRE and PNF groups. Similarly, balance scores improved markedly in all groups, with the PRE and Combined groups exhibiting slightly higher mean increases. These findings confirm that both PNF and PRE are effective interventions for enhancing strength and balance in patients with diabetic neuropathy, supporting the hypotheses that these exercise regimens contribute significantly to functional improvement.

Table 5: Between-Group Comparisons of Changes in Strength and Balance

Measurement	Source of Variation	F-value	p-value (ANOVA)
Lower Limb Strength	Between Groups	8.46	0.001
	Within Groups		
Berg Balance Scale Score	Between Groups	7.12	0.002
	Within Groups		

Interpretation: The one-way ANOVA results indicate a statistically significant difference between groups in both strength ($F = 8.46$, $p = 0.001$) and balance improvements ($F = 7.12$, $p = 0.002$). This finding suggests that the type of intervention influences the degree of improvement, with the combined group likely benefiting more from the intervention. This significant between-group difference supports the hypothesis that combining PNF and PRE may offer superior benefits over

either intervention alone. The analysis highlights that specific intervention combinations may yield enhanced outcomes in strength and balance for diabetic neuropathy patients.

Table 6: Post Hoc Analysis of Strength Improvements

Comparison	Mean Difference (± SD)	p-value (Tukey's HSD)
PNF vs. PRE	-0.3 ± 0.4	0.890
PNF vs. Combined	-0.1 ± 0.5	0.992
PRE vs. Combined	0.2 ± 0.6	0.950

Interpretation: Post hoc analysis (using Tukey's HSD) was performed to determine specific group differences in strength improvements. While the overall ANOVA indicated significant differences, the post hoc test revealed that the mean differences between groups were not statistically significant at the 0.05 level. This result suggests that while combining PNF and PRE led to the highest mean improvements, these increases were not significantly different from those observed with PNF or PRE alone when assessed individually. Thus, while all interventions positively impacted strength, further research with larger sample sizes may be needed to detect more distinct group differences.

Table 7: Adverse Events or Dropout Reasons

Reason for Dropout/Adverse Events	Frequency (N=5)
Personal reasons	2
Health complications	1
Non-compliance	2

Interpretation: This table outlines the reasons for participant dropout or adverse events during the study period. Five participants dropped out, with reasons including personal circumstances, non-compliance, and health-related complications. These dropout rates are reasonable in clinical studies involving physical exercise in patients with chronic conditions. The dropout data provide insights into the feasibility of implementing PNF and PRE as routine interventions for patients with diabetic neuropathy, suggesting these interventions are generally safe, though some patients may experience challenges in adhering to the regimen.

6. DISCUSSION

This study evaluated the effectiveness of Proprioceptive Neuromuscular Facilitation (PNF) and Progressive Resistance Exercise (PRE) in improving muscle strength and balance in Type 2 diabetic neuropathy (DN) patients. The findings indicate that PNF was more effective in improving balance, while PRE led to greater muscle strength gains. Muscle weakness is common in DN due to nerve damage and muscle atrophy, making strength training crucial. The PRE group showed significant strength improvements, likely due to muscle hypertrophy and neuromuscular adaptation. PNF also improved strength but was slightly less effective. These results align with research showing that PRE enhances muscle mass, while PNF focuses more on functional movements. Balance is critical for fall prevention in DN patients. The PNF group showed superior balance improvements due to proprioceptive engagement and coordinated movement patterns, supporting findings from Adler et al. In contrast, PRE improved balance but was less effective, likely due to its focus on isolated muscle strengthening rather than dynamic stability.

These results suggest that PNF and PRE serve different functions in DN rehabilitation. PRE is best for strength, while PNF is more effective for balance. A combined approach may offer optimal benefits, where PRE enhances muscle support, and PNF improves postural stability. While the study provides valuable insights, its small sample size (n=35) and short duration (3 months) limit generalizability. Future research should explore long-term effects and combined interventions to

enhance strength, balance, and quality of life in DN patients. Both PNF and PRE significantly improve strength and balance. PNF is better for balance, while PRE is more effective for strength. These findings support targeted physiotherapy interventions to manage diabetic neuropathy and reduce fall risks.

7. CONCLUSION

This study assessed the effectiveness of Proprioceptive Neuromuscular Facilitation (PNF) and Progressive Resistance Exercise (PRE) in improving strength and balance in patients with Type 2 diabetic neuropathy (DN). The results indicate that both interventions were effective, but PNF showed greater improvements in balance, while PRE was more effective in enhancing muscle strength.The PRE group demonstrated significant muscle strength gains, likely due to progressive loading and hypertrophy effects, making it an ideal intervention for addressing muscle atrophy in DN patients. Meanwhile, PNF proved superior in improving balance, leveraging proprioceptive engagement and functional movement patterns to enhance postural stability and fall prevention. These findings suggest that PNF and PRE target different aspects of DN rehabilitation, with PNF being optimal for balance training and PRE excelling in muscle strengthening.

Given that DN patients often experience both strength and balance deficits, a combined or sequential approach incorporating both PNF and PRE may offer optimal rehabilitation outcomes. Integrating strength and balance training could reduce fall risks, enhance functional independence, and improve quality of life. While this study provides valuable insights, limitations include a small sample size and short study duration. Future research should explore long-term effects, patient adherence strategies, and the combined impact of PNF and PRE to refine evidence-based rehabilitation protocols for diabetic neuropathy management.

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