A COMPARATIVE EFFECTIVENESS OF PNF TECHNIQUE AND THERABAND EXERCISES WITH PNF PATTERN ON UPPER LIMB FUNCTIONS IN PATIENTS WITH DIABETIC NEUROPATHY

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ABSTRACT

BACKGROUND: Diabetes mellitus is one of the commonest metabolic disorder in the world which is also responsible for manifesting other diseases. It has a deleterious effect on the nerves resulting in diabetic neuropathy. Patients with diabetic neuropathy have reported to be more disabled in self-care tasks and housework. But the general therapeutic measures pays less attention to the upper limb problems. Proprioceptive Neuromuscular Facilitation (PNF) is a rehabilitation approach to the disability associated with diabetic neuropathy that is widely used by physiotherapists in many countries. Theraband exercises with PNF pattern on the other hand can be an alternative to the conventional PNF technique in the management of subjects with diabetic neuropathy. So this study was done with an objective of comparing the effectiveness of the PNF technique and the Theraband exercises with PNF pattern along with conventional exercises common to both groups on the upper limb functions in patients with diabetic neuropathy.

METHODS: A simple randomized sampling was done and pre-test and post-test experimental method was used, treating one group with PNF technique and other group with Theraband exercises with PNF pattern for a period of 4 weeks (3 sessions per week on alternative days).

RESULTS: Both the groups showed statistically significant improvement from the baseline. But the group treated with Theraband exercises with PNF pattern on upper limb functions showed improvement as compared to PNF technique on upper limb functions in patients with diabetic neuropathy.

CONCLUSIONS: After 4 week of intervention it has been observed that Theraband exercises with PNF pattern on upper limb functions showed better improvement as compared to PNF technique on upper limb functions in patients with diabetic neuropathy.

KEYWORDS: Diabetic Mellitus, Diabetic Neuropathy, Proprioceptive Neuromuscular Facilitation, Theraband, Michigan Neuropathy Screening Instrument, Upper Extremity Functional Index

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INTRODUCTION

Diabetes mellitus (DM) represents a group of metabolic diseases characterized by chronic high glycemic levels resulting either from defects in insulin production, body tissue response to the insulin, or both. Such abnormalities in the metabolism of carbohydrates, lipids, and proteins result from the paucity of insulin as an anabolic hormone in the cells of the body (Kharroubi and Darwish 2015). There are around 537 million adults around the world with diabetes as per an estimation by the International Diabetes Federation out of which approximately 77 million individuals reside in India, having a higher prevalence (4.3%) as compared with the west (1%-2%) (International Diabetes Federation 2022) (Pradeepa and Mohan 2021) (Bansal et al. 2006).

Diabetic neuropathy (DN) is a common complication of DM with a prevalence in the Indian population ranging from 21% to 31% (Pradeepa et al. 2008). It can have a symmetrical presentation as in diabetic polyneuropathy, painful autonomic neuropathy, painful distal neuropathy, insulin neuritis, and polyneuropathy with glucose impairment; or asymmetrical presentation as in radiculoplexoneuropathies, mononeuropathies, and cranial neuropathy in patients with DM. Distal symmetrical polyneuropathy accounts for 75% of all DN making it the commonest type of DN (Bansal et al. 2006).

The exact pathogenesis of DN though remains unknown but hyperglycemia-induced direct damage to nerve cells and the hyperglycemia-induced decrease in the neurovascular flow resulting in neuronal ischaemia are the most accepted possible causes of DN in patients with DM. These rheological changes brought about by the hyperglycemia result in abnormality in the neuronal, axonal and Schwann cell metabolism, impairing axonal transportation (Edwards 2008).

In common acknowledgement, DN starts from the lower extremities but as the disease progresses, it also affects the upper limbs with advancement from the distal to the proximal, particularly in mononeuropathies. Patients with DN demonstrate a significant reduction in myelinated nerve fibres and endoneurial vascular densities in the upper limbs. These factors may also explain the higher prevalence of compressive neuropathy in patients with DM as its delayed complications (Thomsen et al. 2011). To date, a very small number of studies have investigated the prevalence of clinical and subclinical presentation of DN in the major nerves of the upper limbs including median and ulnar nerves, which may range between 58% to 93% (Bertora et al. 1998) (Yang et al. 2018).

Symptoms include sensory deficits such as loss of tactile sensation, impaired proprioceptive feedback, and painful limb. More importantly, they also include motor deficits such as a decrease in muscle strength, and impaired gross and fine motor skills involving hands. Motor symptoms tend to develop later in the course of the disease All these factors lead to patients reporting of being more disabled in self-care tasks and performing housework, requiring the primary attention of caregivers, physicians as well physiotherapists (Ziegler et al. 1992).

Symptomatic muscle weakness predominantly is responsible for the acquired disability in performing tasks in patients with DN, thus the management protocol must include majors addressing the prevention of any further complications and improvement of muscle strength. One of the physiotherapeutic techniques commonly utilized by therapists to improve muscle strength and restore functional range of motion (ROM) is proprioceptive neuromuscular facilitation (PNF). It is a rehabilitation approach and concept developed by Dr Herman Kabat and Margaret (Maggie) Knot, based on the works of Sir Charles

Sherrington in 1947. Since then it is being practised by physiotherapists and is also a part of the physiotherapy curriculum. Under this therapeutic procedure, the therapist uses the stretch reflex to initiate muscle contraction against the applied resistance, where the tactile stimulation and auditory stimulation from the therapist direct the movement of the patient (Adler et al. 2014).

Instruments such as resistance training machines and free weights are commonly used for resistance exercises to improve muscle strength. These are relatively more expensive and space-occupying than the resistance band that can be used as an alternative to them. Its deformation curve is associated with the increasing tension within it, i.e. the more the band is stretched, the greater the resistance one feel towards its further elongation (Iversen et al. 2016). As shown in a few of the studies, resistance bands or Theraband provide muscle activation to the exercises, similar to that of the other instruments (Aboodarda et al. 2016). Compared to the conventional PNF exercise program with manual resistance whose force may vary throughout the ROM, Theraband exercises in PNF patterns thus can be a better alternative.

Seeing the increasing number of patients with DN in a developing country like India, the demand for a well-accepted physiotherapeutic protocol addressing the upper limbs functional disability is the need of the moment. Many studies have been done testing the effectiveness of the PNF technique and Theraband exercises with PNF pattern individually as a treatment in improving upper limb functional disabilities (Candace et al. 2017) (Kaur 2010). But there is a lack of studies comparing both with respect to the upper limb functions in patients with DN. Therefore, this study was done to compare the effectiveness of PNF techniques versus Theraband exercises with PNF patterns on upper limb functions in patients with DN.

MATERIAL & METHODS

STUDY DESIGN

This structured comparative experimental study was carried out in the Department of Physiotherapy, Sun Valley Hospital, Guwahati, Assam within a period of 6 months. Approval of the Institute Ethical Committee (IEC), College of Physiotherapy and Medical Sciences as per the ethical guidelines for biomedical research on human subjects was taken before starting the study.

SUBJECTS

A total of 62 subjects diagnosed with chronic type 1 and type 2 DM were assessed for DN using detailed motor and sensory assessment and the Michigan neuropathy screening instrument (MNSI) Score. MNSI is a reliable and valid rapid tool consisting of two sections, 'section A' including 15 self-administered questions about neuropathic symptoms and 'section B' including neurological assessment and examination of the lower extremity (Moghtaderi et al. 2006). In the context of this study, only section A was considered. Individuals with impaired sensory and motor findings along with an MNSI score ≥ 10 were considered to be suffering from DN.

Of all, 32 subjects were identified to have DN. They were approached with the proposal of the study and were evaluated for the inclusion and exclusion criteria. 5 individuals were excluded and 3 were not willing to participate (Figure-01). Both male and female subjects, within the age group between 30-60 years, diagnosed with DN with a history of DM for the last 10-20 years and upper limb muscle strength between 3-4 as per manual muscle testing were included. The subjects with non-diabetic neuropathy (vitamin deficiencies, uraemia, thyroid disease, etc. induced), lumbar or cervical radiculopathy, history of cerebrovascular accident, history of upper limb injury, other neurological disorders, and mentally unstable subjects were excluded.

RANDOMIZATION

24 subjects who met the inclusion criteria and agreed to participate were explained in detail about the study and written informed consent was taken in their preferred language before their enrolment in the study. The enrolled subjects were randomized into two groups by simple random sampling. "Group-A" consisted of 12 subjects, who were treated with PNF exercises including dynamic reversal and rhythmic stabilization in both D1 and D2 patterns, whereas "Group-B" consisting of 12 subjects were treated with resistance exercises using the Theraband in PNF D1 and D2 pattern along with conventional exercises including generalised mild stretching

and active ROM exercises that were common to both the groups.

INTERVENTIONS

All the subjects in both groups were treated for a period of 3 sessions alternatively per week for 4 weeks. Each treatment session in both groups started with conventional exercises that were common to both groups, followed by the assigned treatment. The duration of each treatment session was of 45 minutes. The exercises were given on alternative days with each exercise being repeated 8-10 times and 1-2 minutes of rest in between.

In "Group-A" the subjects were treated with the subject in supine lying (Figure-02) and the subjects in "Group-B" were exercised with the Theraband in the sitting posture (Figure-03). The progression was made by increasing the resistance by subsequently using the next-in-line Theraband based on the resistance offered by it, once the subject achieves easiness with the current Theraband. In the beginning, the participants used the yellow band, and progressively the red band, followed by the green and blue were used. In this way, the exercise intensity gradually increased.

MATERIALS USED

The non-latex resistance bands of the company 'Theraband' were used, which were colour coded based on the maximum resistance offered by it. They were in the order of yellow, red, green, and blue where yellow being with least resistance and blue with the maximum.

OUTCOME MEASURE

The Upper Extremity Functional Index (UEFI) was used as the outcome measure. It is a patient-reported questionnaire used to assess upper limb functionality in individuals with upper limb dysfunction. It consists of 20 questions on a 5-point rating scale assessing the level of difficulty in performing activities of daily living using the upper limbs including household and work activities, hobbies, etc. Each item score ranges from 0-4, where 0 represents extreme difficulty and 4 represents no difficulty in performing the task with a cumulative total score maximum of 80 indicating the highest functional status and a minimum score of 0 indicating the lowest functional status. Subjects were asked to circle the number that best describes their level of difficulty in response to each item prior to any intervention and the end of 4 weeks of treatment. UEFI measures show both acceptable reliability and validity with the ICC value = 0.94 (Chesworth et al. 2014).

DATA ANALYSIS

Statistical analysis was performed using Statistical Package for Social Science (SPSS) version 28. The Kolmogorov-Smirnov test was used to test the normality of the data. The Chi-Square test was used to analyse the categorical data and the Independent Sample T-test was used to analyse the continuous data. For outcome measure, within-group analysis was done using the Paired Sample T-test and between-group analysis at baseline as well as following treatment was done using the Independent Sample T-test. The tests were applied at a confidence interval of 95%. For the level of significance p-value set to below 0.05 was considered a significant difference.

RESULTS

The pre- and post-intervention data for both limbs were normally distributed. The groups were homogenous preceding the interventions considering the demographic characteristics and baseline variables as there was a statistically non-significant difference ($p > 0.05$) between the two groups, in the way depicted in Table-01. Following 12 sessions of interventions, the intra-group comparison was suggestive of a statistically significant difference in both Group-A and Group-B concerning the UEFI score for both right and left side upper limbs. This represents that both treatments were effective in improving upper limb functions in subjects with DN. Whereas inter-group comparison was indicative of Group-B showing a statistically significant improvement over Group-A in UEFI score ($p < 0.05$) for the right as well as left upper limbs following treatment (Table-02). This shows that Theraband exercises with the PNF pattern were more effective than the PNF techniques on upper limb functions in patients with DN.

DISCUSSION

This study demonstrated that a 4-week therapeutic treatment program of PNF techniques and Theraband exercises with PNF patterns could improve the functionality of both

right and left upper limbs as measured using the UEFI score. The improvement however in the Theraband exercises with the PNF pattern group was more significant compared to the PNF techniques group.

The within-group development following exercises in both groups can be explained by the betterment in glucose control as induced by the exercises, which progressively slow down or stops the further progression of DN. Even though the therapeutic techniques do not prove to reverse pathogenesis and progression but they help with the control of the aetiology that is DM (Richter et al. 1981).

Previous literature reported that treatment with PNF techniques helps with increasing muscle strength (Hindle et al. 2012) (Nelson et al. 1986); and improving muscle endurance (Kofotolis and Kellis 2006), power output (Klein et al. 2002), and generalised functionality (Kaur 2010), which are mostly related to the increase in the cross-sectional areas and mass of the muscles following PNF training (Kofotolis et al. 2006). Moreover, when treated with PNF techniques also enhances proprioception firing, sensory-motor function, and muscle stabilization (Mathivathani 2018). On top of that, the manual contact and the tailor-made resistance offered by the therapist also played their role by inducing tactile feedback and making the treatment more subject-specific (Candace et al. 2017). All these factors may explain the observed within-group improvement in both upper limbs' functionality as assessed by UEFI seen in Group-A.

Conventionally PNF is a manual interaction technique, whereas the traditional Theraband exercises are practised in the non-PNF pattern. But as an alternative in this study, the resistance exercises were practised with the PNF patterns. However, there is a limited study exploring the therapeutic benefits of resistance exercises with PNF patterns. The use of a Theraband induces muscle activity that progressively increases from the beginning till the end of the range, mirroring the increasing resistance offered by the Theraband with its elongation. This gives an upper hand over the use of free weights as the muscle activation varies throughout the range (Bergquist et al. 2018). The goal of such an approach was to improve overall muscle strength, flexibility, and movement coordination of the upper limbs. When the resistance exercises were reinforced with repeated PNF patterns, it seems to increase coordination, promote joint stability, and improve neuromuscular control (Saliba et al. 1993). It also involves mass movement patterns that are diagonal and spiral in nature crossing the midline of the body, thus making it possible for the patients to learn the desired motor action and incorporate those responses into their daily functional activities. As most of our daily activities involve such types of movement patterns (Adler et al. 2014) (Saliba et al. 1993). The within-group improvement in both upper limbs' functionality seen in Group-B might be explicated by these considerations.

As aforementioned, this study aimed to find out which of the following therapeutic exercises, PNF technique and Theraband exercises with PNF pattern shows better results considering the function of the upper limb as determined by UEFI score among subjects with DN. The result of the study demonstrated that the UEFI score improved in both groups for the right and left upper limbs. But the between-group analysis implicated that the subjects in Group-B, who were treated with Theraband exercises with PNF pattern showed significantly better improvement in the upper limbs' functionality as compared to the PNF techniques group.

The muscle activation was proved to be greatest with the Theraband exercises with PNF pattern as compared to the conventional PNF techniques (Rhyu et al. 2015). The conventional PNF techniques lag behind in terms of the progressive nature of the treatment with the improvement in function, which was archived in Group-B by using different colour-coded Theraband. This might have acted on the psychological aspect of the intervention, offering subjects the feeling of accomplishment and motivating them to continue with the therapeutic program. All these differences between the groups possibly described the outcome variation following interventions.

The small sample size, targeting subjects with both type-I and type-II DM being subjected to a short duration of intervention without any follow-up may have contributed to the potential bias in the study. Hence future studies targeting subjects with either type-I or type-II DM, with large sample size and with longer treatment

duration along with long-term effects analysis is warranted to have greater clarity on the results.

CONCLUSION

Comparable improvement in upper limbs' function as assessed by the UEFI in subjects with DN was demonstrated in both groups. However, with better results gained subjectively in the Theraband exercises with PNF pattern group compared to the PNF technique group, the current findings suggest the use of Theraband exercises with PNF pattern as a better alternative to the PNF technique for the patients with DN.

ABBREVIATIONS

DM- Diabetes Mellitus

DN- Diabetic Neuropathy

MNSI- Michigan Neuropathy Screening Instrument

UEFI- The Upper Extremity Functional Index

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TABLES

Table-01: Demographics & Pre-Intervention Data

Variables	Group-A	Group-B	t-Value	P-Value
Age (Years)	51.41 ± 1.62	52.91 ± 2.84	-1.589	0.126
Male/Female*	05:07	04:08		0.673
Rt PreUEFI	42.92 ± 2.19	43.67 ± 2.19	-0.839	0.411
Lt PreUEFI	42.42 ± 1.88	43.25 ± 1.96	-1.063	0.299

- Rt PreUEFI= Right Upper Extremity Functional Index score at pre-intervention.
- Lt PreUEFI= Left Upper Extremity Functional Index score at pre-intervention.
- Quantitative variables are presented as mean ± SD and categorical variables (*) as the number

Table-02: Intra-Group & Inter-Group Comparison

	Group-A			Group-B			INTER-GROUP
	Pre-intervention	**Post-intervention**	**p-Value**	**Pre-intervention**	**Post-intervention**	**p-Value**	**p-Value**
Rt UEFI	42.92 ± 2.19	61.83 ± 1.08	0.000	43.67 ± 2.19	70.91 ± 2.27	0.000	0.000*
Lt UEFI	42.42 ± 1.88	61.08 ± 1.08	0.000	43.25 ± 1.96	71.67 ± 2.34	0.000	0.000*

- Rt UEFI= Right Upper Extremity Functional Index score.
- Lt UEFI= Left Upper Extremity Functional Index score.
- Quantitative variables are presented as mean ± SD.
- (*) = p-value < 0.05, Group-B statistically significant over Group-A

FIGURES

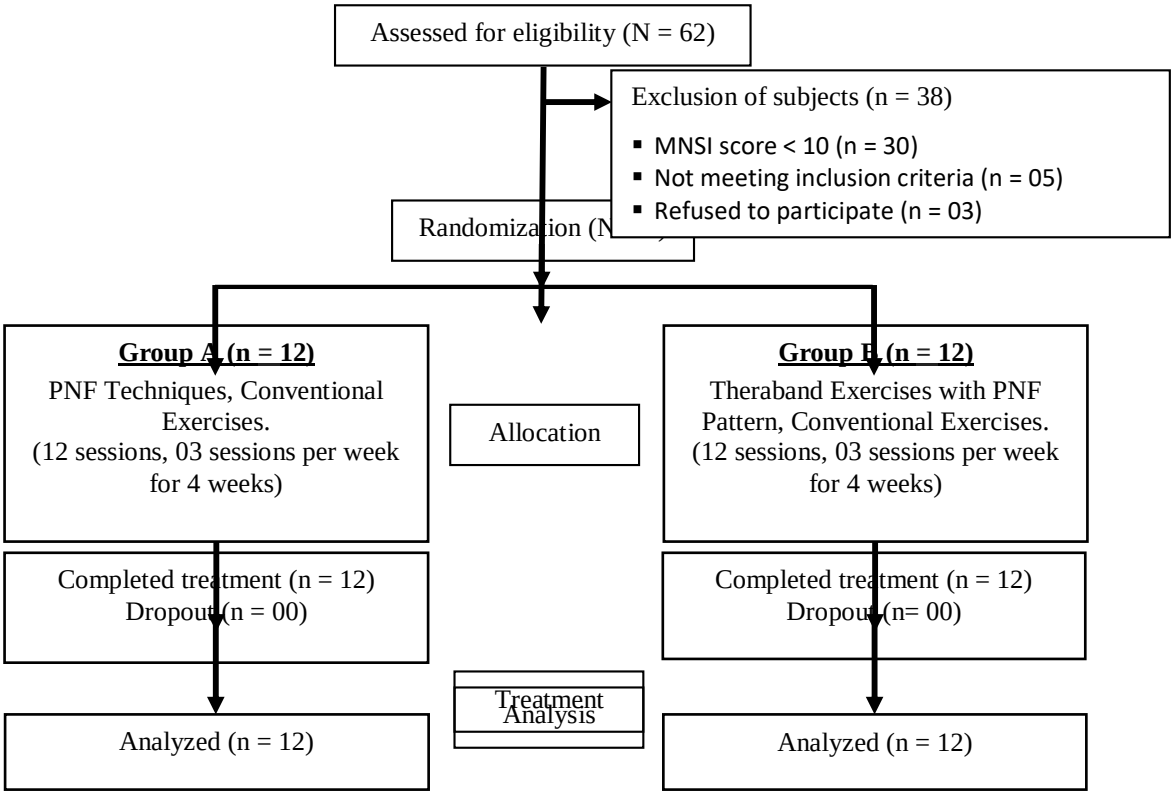

Figure-01: Consort Flow Diagram

Figure-02: PNF Techniques: (A) Dynamic Reversal; (B) Rhythmic Stabilization;

Figure-03: Theraband Exercises With PNF Patterns (Clockwise): (A) D_1 Flexion; (B) D_1 Extension; (C) D_2 Extension; (D) D_2 Flexion