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EFFECT OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION ON SENSORY FUNCTION, SLEEP AND BALANCE IN SUBJECTS WITH DIABETIC POLYNEUROPATHY AFFECTING LOWER LIMBS

Physiotherapy

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ABSTRACT

Background And Objectives: Diabetic polyneuropathy is a common, insidious and debilitating microvascular complication causing sensory symptoms such as numbness, pain, and allodynia. It increases the risk of diabetic foot ulceration by 10 times, which can further lead to non-traumatic amputation thereby increasing fall risk. This study aimed to find the effectiveness of proprioceptive neuromuscular facilitation on sensory function, sleep quality, and balance using a neuropathy disability score, Berg balance scale, and pain and sleep questionnaire 3 index. **Materials And Methods:** Participants were assigned to two groups control and experimental using randomisation, with 15 subjects in each. The experimental group received PNF exercises alone while both the groups received conventional exercises. The study was conducted for 15 sessions over 3 weeks. Pre- and post-evaluation of neuropathy disability score, Berg balance scale, and pain and sleep questionnaire 3 index were performed. **Results:** PNF combined with conventional exercises resulted in significant improvements in NDS(=0.02), BBS (P = 0.01), and PSQ-3 (P =0.02) compared to the conventional exercises group. **Discussion:** The study suggests that using PNF patterns with conventional exercises can improve sensory functions, balance, and sleep quality in diabetic subjects. Fibrosis and disruptions in the transmission of data, axonal transport, as well as vasomotor and trophic functions, can occur due to the excessive pressure applied on neurons and connective tissue. The improvement attained may be due to proprioceptive neuromuscular facilitation patterns and mobilizations of the peripheral nerves having similar positions and motions, which can help reduce sensory deficits and improve balance and sleep quality. **Conclusion:** This study found that combining PNF with conventional exercises resulted in greater improvement of sensory function, balance, and sleep quality in subjects with diabetic polyneuropathy.

KEYWORDS

Diabetic polyneuropathy, Sensations, sleep, Balance, MINSI, PNF

INTRODUCTION

A chronic metabolic disorder, diabetes mellitus is a non-communicable condition that is characterized by persistent hyperglycaemia due to unhealthy lifestyle factors affecting insulin secretion and action mechanisms.[1,2] Hyperglycaemia causes dysfunctions in carbohydrate, fat, and protein metabolism, affecting various body organs. resulting in macrovascular and microvascular complications such as diabetic retinopathy, nephropathy, and neuropathy. In severe cases, this can lead to lower extremity amputation or even death.[3]

Diabetic polyneuropathy is a chronic and progressive disease that primarily affects peripheral nerves presenting with a spectrum of Sensory symptoms ranging from loss of vibration perception, pressure, pain, and joint position sense.[4] Numbness, dysesthesia, pain, and allodynia originate in the feet and tend to spread proximally. These symptoms typically worsen at night and can disrupt sleep patterns.[4,5] Ultimately leads to diabetic foot ulceration, a prevalent cause of non-traumatic amputation. This further increases the risk of falls by fifteen times reducing an individual's ability to maintain balance.[5]

Sensorimotor diabetic neuropathy can have devastating effects on the lower limbs. However, there are various conventional physiotherapeutic interventions such as functional strength training, aerobic exercises, non-weight bearing exercises, stretching exercises, TENS and shock wave diathermy have been shown to improve foot and ankle function, range of motion, gait speed, daily physical activity level, foot muscle strength, glucose levels and balance.[6,7]

Proprioceptive Neuromuscular Facilitation is a therapeutic intervention developed by Herman Kabat in the 1950s. It is used to help patients who have difficulty with movement. PNF aims to enhance strength, coordination, and control of motion, as well as to develop a proper balance between motion and stability. It achieves this by stimulating proprioceptors and increasing endurance.[8,9]

PNF exercises involve performing specific movement patterns that target muscles in diagonal and spiral directions. These movements correspond to the topographic arrangement of the targeted muscles. There are two distinct diagonal movement patterns for the lower limbs, known as D1 and D2. These patterns are performed in flexion and extension.[9]

Need Of The Study:

Diabetic neuropathy (DN) is a common complication of diabetes that can have negative effects on physical activity and independence. It can lead to foot ulcers, lower limb amputation, neuropathic pain, decreased sensation, poor sleep, increased falls, impaired quality of life, and depressive symptoms. Proprioceptive neuromuscular facilitation (PNF) is a promising technique that has been shown to improve sensorimotor functions in different conditions such as multiple sclerosis, cervical radiculopathy, and stroke.

A recent study investigated the effects of PNF on improving sensorimotor dysfunction in diabetic subjects with lower limb neuropathy. The results showed that after three months of treatment, PNF significantly improved muscle strength and sensations in the lower limbs.

Another study compared the effectiveness of functional strength training (FST) and PNF on balance and gait in diabetic neuropathy subjects and found that FST was more effective. However, there are limited studies on the effectiveness of PNF training in diabetic neuropathy subjects in a standing position. It has been recommended to perform a combination of PNF patterns in a standing position as most activities of daily living are performed in a standing position.

Previous studies have also suggested the need for more multicentre randomized controlled trials in this aspect. Until now, no studies have included the effectiveness of PNF on pain and sleep quality. Therefore, this current study aimed to determine the effectiveness of PNF on sensory function, sleep, and balance in subjects with diabetic polyneuropathy affecting the lower limb in a standing position.

Aim Of The Study

To find the efficacy of proprioceptive neuromuscular facilitation on sensory function, sleep and balance in subjects with diabetic neuropathy affecting lower limbs.

Objectives Of The Study:

- To evaluate the effectiveness of proprioceptive neuromuscular facilitation on sensations of lower limbs by using neuropathy disability score and two-point discrimination using a compass esthesiometer in subjects with diabetic polyneuropathy affecting lower limbs.
- To evaluate the effectiveness of proprioceptive neuromuscular facilitation on balance by using the Berg balance scale (BBS) in

subjects with diabetic polyneuropathy affecting lower limbs.
- To evaluate the effectiveness of proprioceptive neuromuscular facilitation on sleep by using Quality of sleep by using the pain and sleep questionnaire 3-index (PSQ-3)in subjects with diabetic polyneuropathy affecting lower limbs.

MATERIALS AND METHODS:

Materials:

The sensory examination kit consists of a Monofilament (10g), Cotton Swab, Tuning Fork (128Hz), and Esthesiometer (20mm), For temperature testing: two test tubes for hot and cold, Reflex Hammer, Wobble board, Stability trainer

a) Sensory kit

b) Wobble board **c) Stability trainer**

Figure-1: sensory kit , wobble board and stability trainer

Inclusion Criteria:

- Subjects fulfilling the Michigan neuropathy screening instrument
- Age 45-60 years
- Manual muscle testing for lower limbs grade >3
- Diabetes since 5 years with sensory symptoms
- HbA1C levels >6.5%
- BBS >35
- Subjects on Regular antidiabetic medications

Exclusion Criteria

- subjects diagnosed with musculoskeletal disorders of lower limbs
- Common peroneal nerve injury
- Peripheral vascular disease
- Comprehension deficits
- Visual deficits
- Vitamin B12 and vitamin D deficiencies
- Diabetic foot ulceration

Procedure For Intervention:

After obtaining informed consent from the subjects who met the inclusion criteria, the subjects were randomly allocated to experimental and control groups using computer-generated numbers. The experimental group was given PNF d1 d2 flexion-extension patterns for 3 sets in a session, 30 minutes/day, five days/week for a total duration of 3 weeks. Each set of exercises consists of 5 repetitions of PNF patterns with a rest interval of 2 minutes. Conventional exercises including sensory and sensory balance training were given for 3 sessions each of 10 repetitions for two sets for one hour whereas the control group was given only conventional exercises.

The subjects of both groups were instructed to perform all the exercises following the given commands under supervision.

TABLE-1:Intervention protocol for experimental and control groups.

Experimental group	Control group
PNF :D1 flexion extension pattern. D2 flexion-extension pattern. Performed in standing position. Conventional exercises Sensory training: Wall slides. Sensory balance training: Bipedal wobble board exercise Unipedal stance, Tandem stance. Total treatment time: each exercise protocol for half an hour	Conventional exercises Sensory training: Wall slides. Sensory balance training: Bipedal wobble board exercise Unipedal stance. Total treatment time: conventional exercise was given twice for one hour

(a)PNF d1 flexion-extension pattern

(b) PNF d2 flexion-extension pattern

FIGURE-2:(a)PNF d1 flexion-extension
(b) PNF d2 flexion-extension

Figure-3: Conventional exercises

Statistical Analysis

Statistical analysis was performed using SPSS 26.0. The data was entered into a Microsoft Excel spreadsheet, tabulated, and analysed using statistical methods.

All 30 participants who fit the inclusion criteria completed the entire study intervention successfully. The study intervention lasted for three weeks of training sessions. Descriptive data was expressed in mean and standard deviation. Demographic data was analyzed using a chi-square test. Within-group analysis was done using a paired t-test, and between-group analysis was conducted using an unpaired t-test.

To assess the treatment's effect before and after the study, within-group and between-group analyses were performed using a t-test. The analysis was based on various outcome measures, including NDS, two-point discrimination, Berg balance score, and pain and sleep questionnaire-3 index.

RESULTS

The demographic details of age, gender, MINSI and hbA1C were analysed using a chi-square test and concluded that there was no

statistically significant difference in demographic characteristics of subjects with diabetic polyneuropathy.

TABLE-2: Comparison of Demographic Variables between experimental group and control group.

variables	Experimental group (N=15)	Contro group (N=15)	P-Value (2 -Tailed)
Age*Years	53.43 ±10.71	54.33 ±10.81	0.701
Gender Male :Female	07:08	09:06	X^2 =1.31 P=0.416
MINSI patient	8.2 ±2.04	8.4±2.20	0.201 P=0.358
MINSI Physical Assessment)	6.00 ±1.41	4.6±1.6	1.31 P=0.564
hbA1C	8.62±2.16	8.48±2.13	0.140 P=0.782

Experimental group

When pre- and post-intervention values for the experimental group were compared, the P-value was found to be statistically significant depicting the improvement in the outcomes of neuropathy disability score with a P-value equal to 0.001, Two point discrimination with a P value of 0.001 on both sides, berg balance scale with P value 0.001 and Pain and sleep quality 3 index equal to 0.001

TABLE-3: Within-group analysis of the pre and post-values of experimental group.

EXPERIMENTAL GROUP					
		MEAN±SD		t-value	p-value
		PRE	POST		
NDS		7.73±1.162	4.6±1.352	14.55	0.001
TDS	RT	2.96±0.171	2.74±0.145	10.98	0.001
	LT	2.926±0.148	2.68±0.145	14.69	0.001
BBS		44.47±1.92	49.93±1.62	18.81	0.001
PSQ-3		170.667±16.6	123.33±15.84	22.94	0.001

Control group:

In the control group, when comparing pre-and post-values, the outcome measures of NDS showed a statistically significant difference with a p-value of 0.001. Both right and left TDS also showed significance with a p-value of 0.001. BBS also showed significance with a p-value of 0.001. The PSQ-3 also had a significant result with a p-value of 0.001.

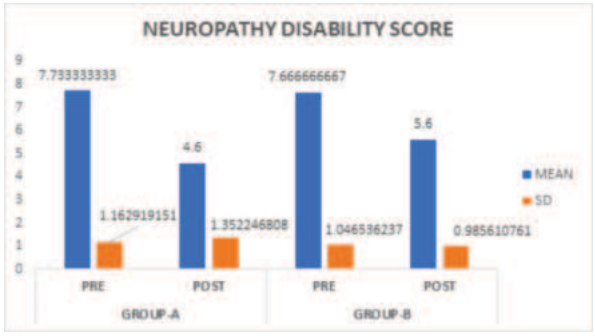
TABLE-4: Within-group analysis of pre and post-values of Control group.

CONTROL GROUP					
		MEAN±SD		t-value	p-value
		PRE	POST		
NDS		7.66±1.04	5.6±0.985	31	0.001
TDS	RT	2.96±0.154	2.73±0.104	11.07	0.001
	LT	2.9±0.185	2.64±0.235	3.98	0.001
BBS		44.47±1.36	47.73±1.22	8.8	0.001
PSQ-3		168±14.2428	137±15.78	7.97	0.001

On comparing the post-intervention values of the experimental and control groups,the experimental group resulted in better improvement in NDS, BBS and PSQ-3 with P-values of 0.02, 0.001 and 0.02 respectively.

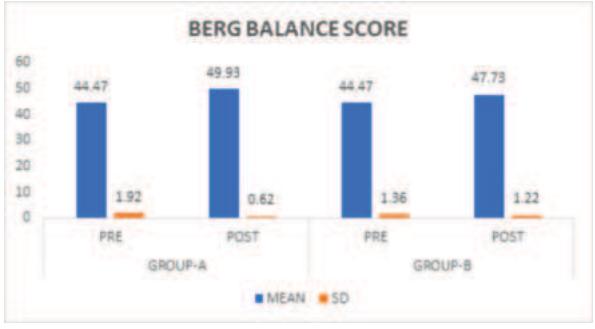
TABLE-5: Post test analysis of Experimental group and Control group

			MD	t-value	p-value
NDS	EXPERIMENTAL GROUP		1	2.3144	0.02
	CONTROL GROUP				
TDS	EXPERI MENTALGROUP	RIGHT	0.01	0.14	0.8
	CONTROL GROUP	LEFT	0.04	0.65	0.5
BBS	EXPERIMENTAL GROUP		2.2	4.19	0.001
	CONTROL GROUP				
PSQ-3	EXPERIMENTAL GROUP		13.7	2.397	0.02
	CONTROL GROUP				

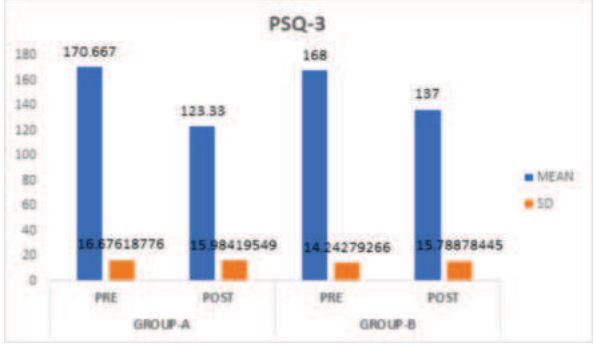


Graph-1: Graphical representation depicting Comparison of NDS with mean and SD of pre and post-values in two groups.

Graph-2: Graphical representation depicting comparison of TDS with mean and SD of pre and post-values in two groups



Graph-3: Graphical representation shows a comparison of berg balance score with mean and SD of pre and post-values in both the groups



Graph-4: Graphical representation shows a comparison of PSQ-3 with mean and SD of pre and post-values in both groups

DISCUSSION

Distal symmetric diabetic polyneuropathy is a prevalent type of neuropathy, responsible for around 75 percent of cases. The disease is

characterized by a persistent and gradual progression leading to various degrees of sensory and motor dysfunction, pain, gait abnormalities, postural instability, nerve palsies, ulcers, infections, burns, gangrene, and Charcot's disease.

The peripheral nerve plays a crucial role in transmitting various types of data to the central nervous system, including information related to exteroception, proprioception, thermaesthesia, stereo-gnosis and joint position sense. However, the pressure exerted on neurons and connective tissue can cause fibrosis and interruptions in data transmission, leading to blood supply impairment and reduced physical capacity in subjects. The nerve could be the cause of its own symptoms or contribute to abnormal body movements and misalignment due to the confusing information provided by "Nervi nervorum".[10]

The present study, aimed to investigate the effectiveness of proprioceptive neuromuscular facilitation on sensory function, sleep quality, and balance using an NDS, PSQ-3 and BBS.

This study concluded that there was a significant improvement in PNF combined with conventional exercises on NDS(P>0.02)PSQ-3(P>0.02) and BBS with(p>0.001) and based on statistical analysis, the null hypothesis was rejected except for two-point discrimination.

The use of proprioceptive neuromuscular facilitation (PNF) patterns in combination with conventional exercises has been found to have potential benefits for subjects with diabetic polyneuropathy.

The present study revealed a significant improvement in NDS and PSQ-3 in the experimental group when compared control group with a p-value equal to 0.02. This improvement was due to the modulation of tension within all structures of the nerve can provide the central nervous system with the desired information, leading to improved motor performance. The use of PNF patterns which are similar to mobilization techniques may have helped to reduce tension in structures, improve blood supply, and ultimately reduce sensory deficits along with pain.

The case report done by Karin Jeanbart A, and Cornelia Tanner-Bram (2021) supporting our present study findings concluded that using the PNF-based rehabilitation approach resulted in a significant improvement in pain, nerve mobility, and balance in subjects with chronic pain. This approach helped to increase the supply of oxygen to the nerves and reduce pain, leading to restored movement patterns and improved daily activities If standard strengthening and mobilization techniques are ineffective, PNF could potentially be used as an alternative approach to alleviate chronic pain..[11]

A study done by Kamaljeet Singh, Lalit Arora and Reena Arora (2016) also supports the present study findings. A study was conducted to examine the impact of the PNF technique on sensorimotor function in individuals with diabetic neuropathy. The study findings revealed a statistically significant improvement in sensorimotor function. (p>0.05)[12]

The current study showed a significant improvement in Berg balance score in both the groups and on the comparison, the experimental group has shown significant improvement with a p-value of 0.001. An enhanced proprioceptive firing from the cutaneous receptors was observed due to training of proprioception in a standing position, which resulted in an improvement. The use of new and improved feedback techniques appears to have a positive impact on motor learning, which can in turn have a beneficial effect on balance. In individuals with diabetic neuropathy, proprioceptive training can be a simple and cost-effective approach for improving functional balance. This could help to reduce the risk of falls and improve overall quality of life. PNF movements are executed in a diagonal pattern that follows the body's natural muscular topography, similar to physiological movements like walking. Research suggests that using PNF techniques can lead to greater activation of both agonist and antagonist muscles involved in balance, achieved by reducing co-activation.

Aditya Wajhe and Jayasri Kale conducted a study to compare the effectiveness of balance training exercise and PNF exercise in improving balance. The study concluded that diabetic peripheral neuropathy patients should include both PNF exercises and balance training exercises in their daily exercise routine to enhance their mobility and functional status..[13]

Therefore, PNF incorporated along with conventional exercise is beneficial in improving sensations, balance and quality of sleep in subjects with diabetic polyneuropathy affecting lower limbs.

CONCLUSION

This study evaluated the effectiveness of PNF on sensory function, balance and sleep in diabetic polyneuropathy subjects affecting lower limbs and concluded that there is a significant improvement with PNF treatment along with conventional treatment than the conventional treatment only. Therefore, PNF combined with conventional therapy can be useful in subjects with diabetic polyneuropathy with sensory impairment and also can improve balance and sleep quality suggesting the potential therapeutic effects in specific.

Limitations:

- The study had a smaller sample size.
- No further follow-up was conducted.
- The immediate effects of PNF on blood glucose could not be measured.
- The effect of PNF on NCS could not be recorded.
- There was no instrumentation used to record joint proprioception.

Recommendations:

- Future studies should have a larger sample size.
- Further follow-up should be conducted.
- The immediate effects of PNF on blood glucose should be measured.
- The effect of PNF on NCS should be recorded.

APPENDIX

PNF : The starting and terminal positions of specific movements in the D1 and D2 patterns for the lower extremities are mentioned below.

Pattern of movement	Joint	Starting position	Terminal position
D1 moving into flexion	Toes	Flexion	Extension
	Ankle & foot	Plantarflexion, Eversion	Dorsiflexion, Inversion
	Tibia	External rotation	Internal rotation
	Knee	Extension	Flexion
	Hip	Extension Abduction Internal rotation	Flexion Adduction External rotation
D1 moving into extension	Toes	Extension	Flexion
	Ankle & foot	Dorsiflexion, Inversion	Plantarflexion, Eversion
	Tibia	Internal rotation	External rotation
	Knee	Flexion	Extension
	Hip	Flexion Adduction External rotation	Extension Abduction Internal rotation
D2 Moving into Flexion	Toes	Flexion	Extension
	Ankle & foot	Plantarflexion Inversion	Dorsiflexion Eversion
	Tibia	External rotation	Internal rotation
	Knee	Extension	Flexion
	Hip	Extension Adduction External rotation	Flexion Abduction Internal rotation
D2 Moving into extension	Toes	Extension	Flexion
	Ankle & foot	Dorsiflexion Eversion	Plantarflexion Inversion
	Tibia	Internal rotation	External rotation
	Knee	Flexion	Extension
	Hip	Flexion Abduction Internal rotation	Extension Adduction External rotation

Conventional Exercises

Exercises	Level -1	Level -2	Level-3	Level-4
Sensory training	Wall slides First 3 sessions:20 repetitions Next 3	Wall slides First 3 sessions:20 repetitions Next 3	Wall slides First 3 sessions:20 repetitions Next 3	Wall slides First 3 sessions:20 repetitions Next 3

Exercises	Level -1	Level -2	Level-3	Level-4
	sessions:20 repetitions x 2 sets	sessions:20 repetitions x 2 sets	sessions:20 repetitions x 2 sets	sessions:20 repetitions x 2 sets
Balance training (sensory component)	Bipedal wobble board exercises (bidirectional wobble board) First 3 sessions :3min Next 3 sessions :3min x 2sets	Bipedal wobble board exercises (bidirectional wobble board) First 3 sessions :3min Next 3 sessions :3min x 2sets	Bipedal wobble board exercises (multidirectional wobble board) First 3 sessions :3min Next 3 sessions :3min x 2sets	Bipedal wobble board exercises (multidirectional wobble board) First 3 sessions :3min Next 3 sessions :3min x 2sets
	Unipedal stance First 3 sessions :3min Next 3 sessions :3min x 2sets	Unipedal stance First 3 sessions :3min Next 3 sessions :3min x 2sets	Unipedal stance First 3 sessions :3min Next 3 sessions :3min x 2sets	Unipedal stance First 3 sessions :3min Next 3 sessions :3min x 2sets
	Tandem stance: First 3 sessions:20 repetitions Next 3 sessions:20 repetitions x 2 sets	Tandem stance: First 3 sessions:20 repetitions Next 3 sessions:20 repetitions x 2 sets	Tandem stance: First 3 sessions:20 repetitions Next 3 sessions:20 repetitions x 2 sets	Tandem stance: First 3 sessions:20 repetitions Next 3 sessions:20 repetitions x 2 sets

REFERENCES

1. Patane, G. R., & Kanase, S. B. (2022). Designing and development of diabetic exercise mat and its effect on sensory-motor dysfunction in chronic diabetic individuals. *Asian Pac J Health Sci*, 2, 40–43.
2. Pot GK, Battjes-Fries MC, Patijn ON, van der Zijl N, Pijl H, Voshol P(2020). Lifestyle medicine for type 2 diabetes: practice-based evidence for long-term efficacy of a multicomponent lifestyle intervention (Reverse Diabetes2 Now). BMJ Nutr Prev Health. ;3(2):188–95.
3. Banday, M. Z., Sameer, A. S., & Nissar, S. (2020). Pathophysiology of diabetes: An overview. Avicenna Journal of Medicine, 10(4), 174–188.
4. Ahmad, I., Noohu, M. M., Verma, S., Singla, D., & Hussain, M. E. (2019). Effect of sensorimotor training on balance measures and proprioception among middle and older age adults with diabetic peripheral neuropathy. Gait & Posture, 74, 114–120.
5. Braffett, B. H., Gubitosi-Klug, R. A., Albers, J. W., Feldman, E. L., Martin, C. L., White, N. H., Orchard, T. J., Lopes-Virella, M., Lachin, J. M., Pop-Busui, R., & DCCT/EDIC Research Group. (2020). Risk factors for diabetic peripheral neuropathy and cardiovascular autonomic neuropathy in the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) study. Diabetes, 69(5), 1000–1010.
6. Akbari, J., Hosseinifar, N., Naimi, M., Mikaili, S. S., & Rahbar, S. (2020). The efficacy of physiotherapy interventions in mitigating the symptoms and complications of diabetic peripheral neuropathy: A systematic review. J Diabetes Metab Disord, 19(2), 1995–2004.
7. Muhamad Ibnu Sina1*, A. F. &. K. M. I. (2019). Association between diabetic neuropathy symptom and Diabetic Neuropathy Examination with berg balance scale in diabetic neuropathy patients. Int. j. Res. Sci. Manag.
8. Adler, S. S., Beckers, D., & Buck, M. (2014). PNF in Practice
9. Bharaneedhran T, Dhanalakshmi D. Efficacy of proprioceptive neuromuscular facilitation for improving balance in diabetic neuropathy. Ijcrt.org.
10. Wolny, T., Saulicz, E., Gnat, R., & Kokosz, M. (2010). Butler's neuromobilizations combined with proprioceptive neuromuscular facilitation are effective in reducing of upper limb sensory in late-stage stroke subjects: a three-group randomized trial. Clinical Rehabilitation, 24(9), 810–821.
11. Jeanbart K, Tanner-Bräm C(2021). Mobilization of the neurodynamic system using proprioceptive neuromuscular facilitation decreases pain and increases mobility in lower extremities and Spine-A case report. J Bodyw Mov Ther,27,682–91.
12. Singh, K. (2016). Effect of proprioceptive neuromuscular facilitation (PNF) in improving sensorimotor function in subjects with diabetic neuropathy affecting lower limbs. Int J Physiother, 3(3).
13. Dr, W., Kale, A., & Dr. (2020). To study 'effectiveness of balance training exercise and pnf exercise versus only balance training exercise in subjects with diabetic peripheral neuropathy. INDIAN JOURNAL OF APPLIED RESEARCH, 1–3.