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Effectiveness of Proprioceptive Neuromuscular Facilitation on Spasticity in Hemiplegia: Randomised Controlled Trial

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ABSTRACT

Introduction: *Stroke is one of the major causes of morbidity and mortality worldwide. Spasticity is one of the positive feature of stroke. Hence, this study aimed at evaluation of effectiveness of propriocetive neuromuscular facilitation (PNF) over conventional physiotherapy on spasticity in hemiplegia.*

Materials and Methods: *Randomised controlled trial was done on 30 stroke patients with minimum Grade 1 spasticity. The subjects were randomly allotted for intervention period of 4 weeks into two groups with those receiving PNF technique and conventional physiotherapy. The spasticity and functional independency was evaluated using Ashworth Scale and Barthel index respectively results obtained were compared.*

Results: *The Ashworth Scale in PNF group showed significant improvement from 2.46±0.51 to 1.13±0.35 as compared to conventional group with 2.4±0.5 to 1.86±0.35. The Barthel index in PNF group showed significant improvement from 54.33±7.52 to 85±5 as compared to conventional group with 53±2.53 to79±7.6. The ROM also had shown significant improvement in PNF group.*

Discussion: *Both the techniques showed significant reduction in spasticity measured on Ashworth scale, with PNF being more effective ($p<0.0001$). The improvement in Barthel Index showed both the interventions to be effective with PNF being more effective in improving the functional independency ($p<0.0001$). Patients treated with PNF showed significant improvement in shoulder joint abduction, adduction ($p<0.0001$); elbow joint flexion, extension ($p=0.0042$); hip joint external rotation ($p=0.0098$) and flexion ($p=0.0091$) and extension ($p=0.0091$) of knee joint as compared to conventional group.*

Conclusions: *PNF technique is significantly effective over conventional physiotherapy for reducing spasticity and improving functional activities in hemiplegia.*

Keywords: *Barthel Index, Modified Ashworth Scale, Range of motion, Stroke.*

INTRODUCTION

Stroke, described as the sudden development of a neurologic deficit caused by abnormalities of blood supply [(1)] is one of the major causes of morbidity and mortality worldwide [(2)]. Damage to the pyramidal tract and its accompanying parapyramidal (corticoreticulospinal) fibers gives rise to the upper motor neuron syndrome [(3)], including positive and negative features. Positive features include spasticity and abnormal postures and negative features include those that have been lost such as strength and dexterity [(4)].

Spasticity is abnormal muscle tone recognised clinically as resistance to passive muscle stretch which increases with velocity of stretch [(5)]. It is more formally defined as: 'a motor disorder characterised by velocity dependent increase in tonic stretch reflexes with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex' [(6)].

Stroke affecting the motor cortex or internal capsule commonly produces initial hypotonia and absent tendon jerks, followed several weeks later by spastic hypertonia in the antigravity muscles [(5)]. The upper limb adopts an adducted posture at the shoulder and a flexed posture at the elbow and wrist, with the fingers flexed into the palm. In the lower limb there is hip and knee extension, with plantarflexion at the ankle [(5)].

Because of spasticity the affected muscles and tendons become tight and stiff which causes problems in performing daily activities, like walking, standing and performing daily chores. Generally symptoms include exaggerated muscle tone, uncontrollable movement such as rapid muscle contractions and leg-crossing, fixed joints, exaggerated tendon reflexes and shortened tendons [(5)].

There are various schools of thoughts and treatment protocols are available for reducing spasticity which includes passive and active movement-based approaches. Passive movement-based approaches include combination of neural facilitation techniques, rhythmic passive movements and proprioceptive neuromuscular facilitation. Active movement-based approaches include active exercise interventions such as hydrotherapy and walking [(5)].

PNF techniques rely mainly on stimulation of the proprioceptors for increasing the demand made on the neuromuscular mechanism to obtain and facilitate its response. It uses proprioceptive, cutaneous, auditory input to produce functional improvement in motor output and in the rehabilitation of many injuries [(7)]. The techniques of PNF are composed of both rotational and diagonal exercise patterns. The exercise pattern is initiated with the muscle groups in the lengthened or stretched position, the muscle group is then contracted, moving the body part though the range of motion to a shortened position. Putting the muscles needed to be stimulated in a stretched position [(7)].

The present study was done to evaluate spasticity, functional activities in hemiplegic and to study the effectiveness of PNF over conventional physiotherapy for reducing spasticity and improving functional activities in hemiplegia.

METHODS

Randomised controlled trial was done on 30 stroke patients with minimum Grade 1 spasticity on Ashworth Scale. The subjects were randomly allotted for intervention period of 4 weeks into two groups with those receiving PNF technique (Group A=15, mean age 58.06±8.79) and conventional physiotherapy (Group B=15, mean age 59.73±9.52). Spasticity and functional independency was evaluated using Ashworth Scale and Barthel index respectively on day1, at the end of second week and fourth week and the results obtained were compared.

PNF Technique: The intervention of Group A included patterns of facilitation i.e.D1 and D2 flexion extension for both upper limb and lower limb with stretch stimulus and stretch reflex. The D1 flexion for upper limb included flexion-abduction with lateral rotation and D1 extension included extension-adduction with medial rotation. The D2 flexion included flexion-

adduction with lateral rotation and D2 extension included extension-abduction with medial rotation. Similarly, for lower limb, D1 flexion included flexion-abduction with medial rotation and D1 extension included extension-adduction with lateral rotation. The D2 flexion included flexion-adduction with lateral rotation and D2 extension included extension-abduction with medial rotation. The duration of treatment session was 30 to 40 minutes including the rest period and was done thrice a week for 4 weeks.

Conventional Physiotherapy: The intervention of Group B included stretching with three repetitions each, strengthening with weight cuffs with 10 seconds hold and 10 repetitions each, wobble board exercises were given for 2-3 minutes progressing by forward stepping, backward stepping on wobble board along with weight shifting, Gait training at parallel bar. The duration of treatment session was 40 to 50 minutes including the rest period and was done thrice a week for 4 weeks.

The post-treatment results were noted and compared with the pre-treatment findings for spasticity using Ashworth scale, Barthel index and range of motion. The statistical analysis was done using ANOVA test and unpaired t-test.

RESULTS

Table 1 demonstrates improvement in spasticity on Ashworth scale of patients treated with PNF was extremely significant ($p<0.0001$) as compared to those treated with conventional physiotherapy. Also patient's participation in activities of daily living measured on Barthel index showed extremely significant improvement in PNF group ($p<0.0001$) as well as conventional physiotherapy ($p<0.0001$).

Table 2 demonstrates that patients treated with PNF showed significant improvement in shoulder joint abduction, adduction ($p<0.0001$); elbow joint flexion, extension ($p=0.0042$); hip joint external rotation ($p=0.0098$) and flexion ($p=0.0091$) and extension ($p=0.0091$) of knee joint as compared to conventional group.

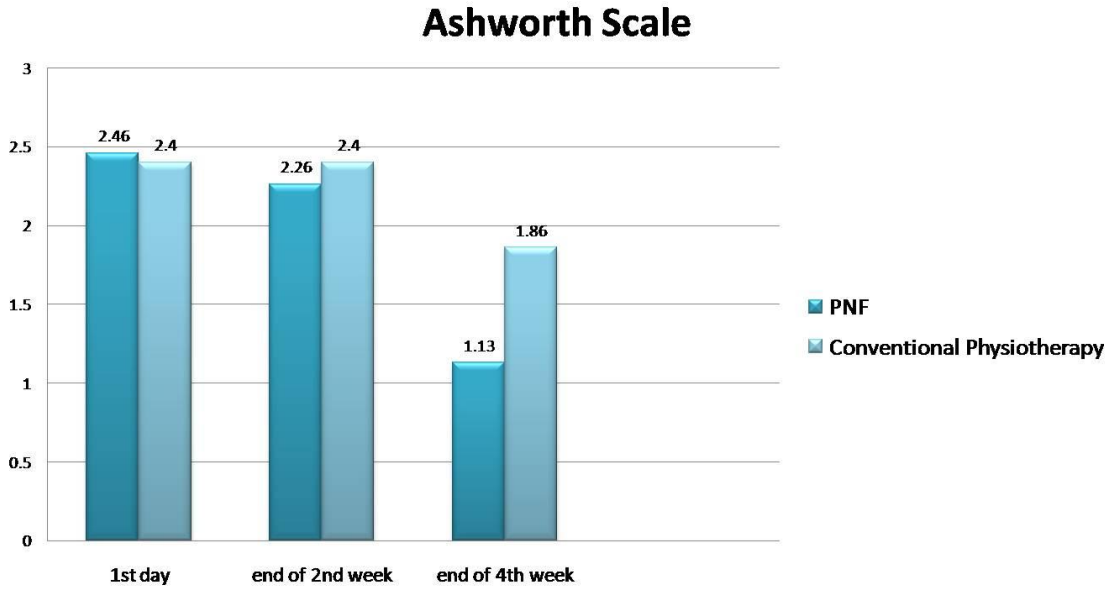
Table 1 demonstrates improvement in spasticity on Ashworth Scale and functional activities on Barthel Index

	Ashworth Scale			**Barthel Index**		
	PNF	**Conventional Physiotherapy**	**p value**	**PNF**	**Conventional Physiotherapy**	**p value**
1st day	2.46±0.51	2.4±0.5	0.724	54.33±7.52	53±2.53	0.5209
end of 2nd week	2.26±0.45	2.4±0.5	0.456	64.66±15.29	53±2.53	0.0069
end of 4th week	1.13±0.35	1.86±0.35	<0.0001	85±5	79±7.6	0.0164
p value	<0.0001	0.003		<0.0001	<0.0001	

Table 2 demonstrates improvement in range of motion.

Joint Movement		**Pre**			**Post**		
		Conventional physiotherapy	**PNF**	**p value**	**Conventional physiotherapy**	**PNF**	**p value**
		Mean±SD			Mean±SD		
Shoulder	Flexion	101.33±18.07	106.33±24.10	0.4986	124.66±17.16	144.66±17.57	0.0038
	Extension	22.66±7.52	25.33±9.53	0.4025	37.66±12.79	47.33±12.65	0.0468
	Abduction	104.66±9.15	108±18.20	0.5315	130.66±8.83	149.33±13.74	0.0001
	Adduction	104.66±9.15	108±18.20	0.5315	130.66±8.83	149.33±13.74	0.0001
	External Rotation	48±13.20	43.66±12.60	0.3657	65.66±10.15	69.66±10.25	0.2923
	Internal Rotation	41±7.60	37.33±10.15	0.2725	58.33±7.23	64.66±10.08	0.058
Elbow	Flexion	107.33±7.98	105.33±12.45	0.6048	128.33±5.23	135.33±6.93	0.0042
	Extension	107.33±7.98	105.33±12.45	0.6048	128.33±5.23	135.33±6.93	0.0042

Wrist	Flexion	48±9.22	49.33±13.61	0.7558	63.33±6.17	72.33±11.78	0.014
	Extension	44.66±10.60	39.33±9.61	0.16	58.66±9.15	64.66±4.41	0.03
	Ulnar Deviation	11.33±3.51	9.66±3.99	0.2354	24.66±5.81	26.66±6.17	0.3688
	Radial Deviation	9±2.07	8±2.58	0.2467	19.66±4.80	24.33±6.77	0.0382
Hip	Flexion	78.66±13.02	62.66±18.21	0.0099	96.33±11.56	94±20.19	0.7007
	Extension	13.33±6.98	9.66±6.11	0.1373	25.33±9.15	28.66±3.51	0.1987
	Abduction	29.66±5.49	23.66±6.39	0.0102	40.33±4.806	43.66±2.28	0.022
	Adduction	14.33±4.57	11.66±5.23	0.1486	24±5.07	28.33±9.57	0.1326
	External Rotation	28.66±4.80	24±6.32	0.0307	41±4.30	44.33±1.75	0.0098
	Internal Rotation	24±5.07	22±7.51	0.4	35.66±5.93	41±6.08	0.0213
Knee	Flexion	100.66±5.93	98±6.76	0.2607	117.33±9.42	126.66±8.79	0.0091
	Extension	100.66±5.93	98±6.76	0.2607	117.33±9.42	126.66±8.79	0.0091
Ankle	Dorsiflexion	9±2.07	7±2.53	0.0251	18.33±2.44	20±0.25	0.0175
	Plantarflexion	29.33±7.76	24±7.36	0.0638	41.33±5.81	46.66±4.88	0.0111
	Inversion	14±3.87	13±6.76	0.623	28±4.55	33±4.55	0.0055
	Eversion	8.33±2.44	6.66±2.44	0.0719	13.33±2.44	14.6±1.05	0.0756



Graph 1: improvement in spasticity on Ashworth Scale

DISCUSSION

This study was a randomised controlled trial for the evaluation of effectiveness of PNF over conventional physiotherapy in stroke patients. Both the techniques showed significant reduction in the spasticity measured on Ashworth scale, with PNF being more effective than conventional physiotherapy ($p<0.0001$). The study done by Kawahira *et al.*[8] (2004) had demonstrated similar results where rehabilitation programme comprising mainly the PNF technique led to improvement in voluntary movement of the hemiplegics. Improvements of the patients motor function is possible even years after initial lesion when mobilization of the nervous system is included in the treatment program [9]. Sullivan PE et al.[10] mentioned PNF to be one of the major therapeutic approaches aimed at improving the important features necessary for the functional activities of hemiplegic patients, such as muscular tone, strength and flexibility.

The improvement in activities of daily living was assessed with Barthel Index showing both the interventions to be effective with PNF being more

effective in improving the functional independency of stoke patients (p<0.0001). As per Gardiner [7] PNF contains more of skilled diagonal movements emphasising more on functional activities. The patterns of movements used are spiral and diagonal and they are closely allied to those of normal functional movements of daily living. Wang RY [11] concluded that use of PNF technique results in increased gait speed and cadence. Pil Neo Hwangbo *et al.* [12] concluded that both traditional rehabilitation therapy and PNF neck pattern exercises are effective in enhancing the ability of chronic stroke patients to control the trunk and to maintain balance.

Patients treated with PNF showed significant improvement in shoulder joint abduction, adduction (p<0.0001); elbow joint flexion, extension (p=0.0042); hip joint external rotation (p=0.0098) and flexion (p=0.0091) and extension (p=0.0091) of knee joint as compared to conventional group. PNF stretches the antagonist which leads to stimulation of stretch reflex leading to reciprocal inhibition of agonist resulting in increase in the ROM [7]. Proprioceptors situated in the muscle spindles are stimulated by stretching, which increases the intramuscular tension. Stimulation of the muscle spindle elicits a reflex contraction of the muscle provided the stimulus is of threshold value along with intact reflex arc. Bombardment of dormant anterior horn cells by impulses initiated from the spindles increases central excitation and facilitates stimulation of the cells [7] leading to improvement in functional activities and ROM.

CONCLUSION

PNF technique is significantly effective over conventional physiotherapy for reducing spasticity and improving functional activities in hemiplegia.

LIMITATION

1. Spasticity being reversible in absence of intervention, this study could not assess whether the effect of interventions were retained after the intervention has stopped.

FUTURE SCOPE OF STUDY

1. Follow up study can be done without intervention to study the retained effect for short and long term goals.
2. Comparative study of supervise and non-supervise intervention can be done.

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