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PNF in acute stroke

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Introduction

Stroke is one of the leading causes of death and disability in India. The estimated adjusted prevalence rate of stroke range, 84-262/100,000 in rural and 334-424/100,000 in urban areas. The incidence rate is 119-145/100,000 based on the recent population based studies.[1] There are several different approaches to physiotherapy treatment after stroke. These can broadly be divided into approaches that are based on neurophysiological, motor learning, or orthopaedic principles. Some physiotherapists base their treatment on a single approach, whereas others use a mixture of components from a number of different approaches.[2] Neurophysiological approaches are based on the knowledge of understanding the physiology that helps CNS function and these approaches utilize plasticity. It contributes to the adaptation and reorganization of the CNS function. Corrects and repeated stimulation through these approaches can lead to the non involved part of the brain functionally compensating for the affected area of the brain. These approaches are:

a) Muscle- reeducation approach (1920s)

b) Sensory- motor approach (Rood, 1940s)

c) Movement-Therapy Brunnstrom (1950s)

d) NDT/Bobath (1960-70s)

e) PNF approach (Knot and Voss, 1960-70s)

f) Sensory integration (Jenn Ayer (1920-1989)

g) Task- Oriented approach (1990s)

Propioceptive Neuromuscular Facilitation (PNF) is the neurophysiological approach in which impulses from the periphery are facilitated to the central nervous system through the stimulation of sensory receptors present in muscles and around the joints by stretch, resistance, traction, approximation and audiovisual command to the patient.

PNF was developed by Dr. Harman Kabat (MD) and Margret Ross during 1940's and early 1950's. Initially the approach was developed to treat the patients with neurological dysfunctions. He studied researcher such as Sherrington, Gellhorn, Coghill, Gesell, Helebrandt, and others. These authors reported that traction, stretch reflex, irradiation, resistance and other proprioceptive input could influence a muscle response. PNF integrates the use of spiral and diagonal pattern specific of movements (Figure 1 & 2) (with antagonist and agonist muscles) with procedures and superimposed techniques that induce the muscular contraction, relaxation and muscle strength.[2] PNF applies neurophysiological principle of sensory/motor system to manual evaluation and treatment of neuromuscular skeletal system. PNF provides the therapist with an efficient mean for evaluating and treating neuromuscular and structural dysfunctions.[3–7]

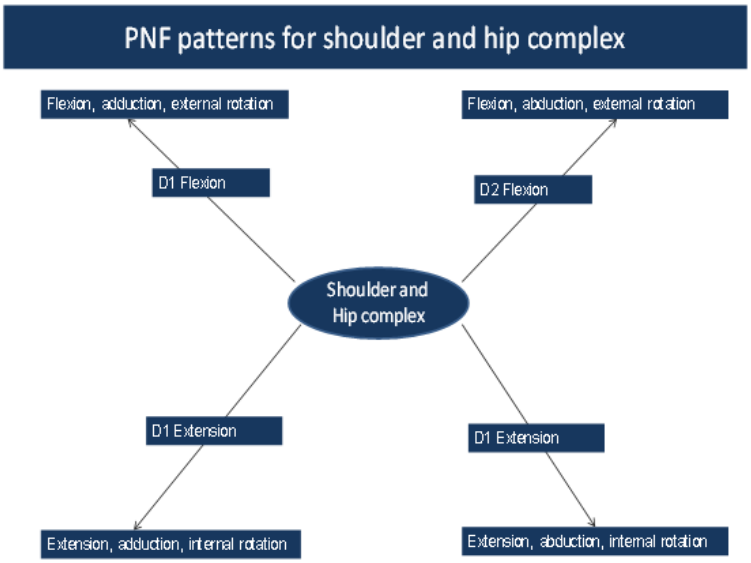

Figure 1 Diagonal patterns of PNF for shoulder and hip complex.

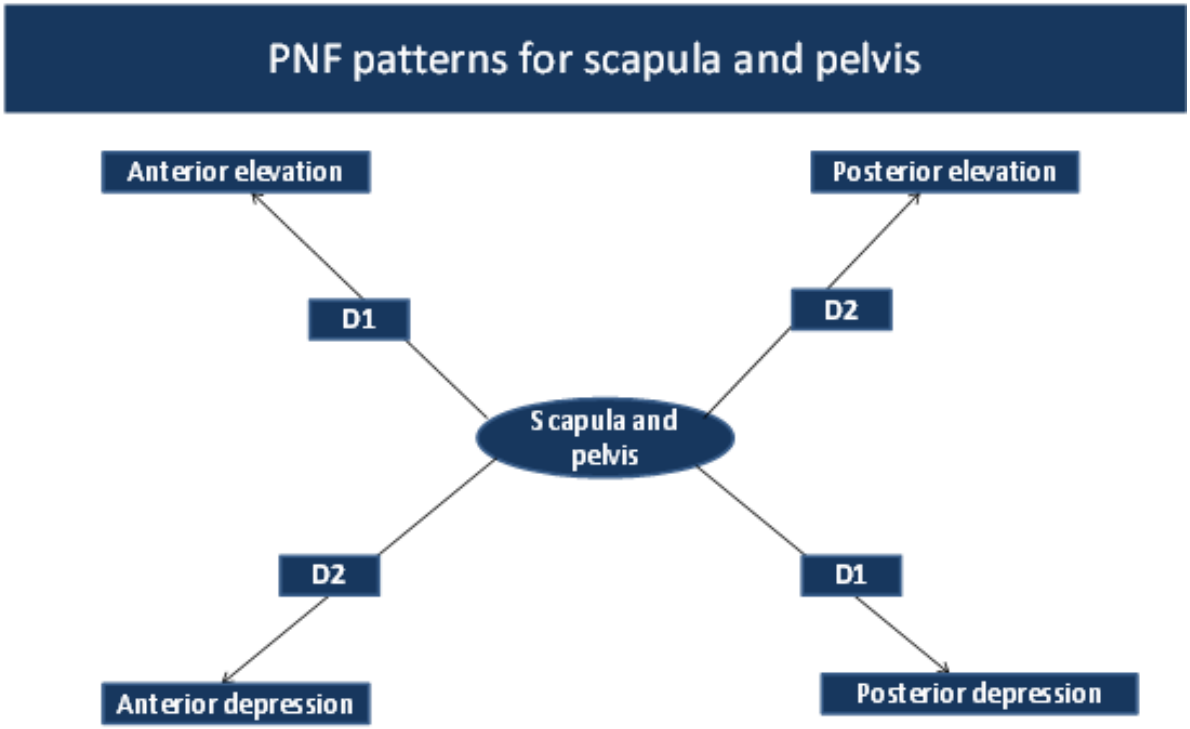

Figure 2 Diagonal patterns of PNF for scapula and pelvis.

The basic procedure used for PNF application is

a. Resistance**:** To increase muscle strength, motor learning and motor control.

b. Irradiation and reinforcement: Assistance to weak muscle by surrounding strong muscles by spread of response to stimuli.

c. Manual contact: To increase awareness, to guide direction and to give resistance.

d. Body position and body mechanics: Guidance, control of motion, balance and stability.

e. Verbal stimulation (Commands): For guiding the patient about the movement.

f. Vision: For reinforcement and guiding motion

g. Traction and Approximation: For stimulation of proprioceptors in muscles and around joint

h. Stretch: Stretch may be quick or sustained. Quick stretch facilitates the muscle contraction

i. Timing: Promote normal timing and increase muscle contraction through "timing for emphasis".

j. Patterns: Synergistic mass movements, components of functional normal motion in diagonal and spiral pattern.[8] (Figure 3)

Basic neurophysiological principles thought to involve while PNF application

I. **After Discharge:** Effect of the stimulus increases even after the stimulus stops. So if the strength duration of the stimulus is increased, the after discharge will also be increased and this leads to feel the increase in power.[1]

II. **Temporal summation:** Weak stimuli of subliminal potential combine in certain period of time to cause excitation.

III. **Spatial summation:** Stimuli applied to various body parts reinforce each other and summate to cause excitation. Temporal and spatial summation, these neurophysiological phenomena is thought to help in generating response in weak muscles.

IV. **Irradiation:** This is the spread of response to the surrounding. This may be the result of increase in number or strength of stimuli. This *"irradiation"* or *overflow* effect, can occur when,

a. The stronger muscle groups help the weaker groups in completing a particular movement.

b. This cooperation leads to the rehabilitation goal of return to optimal function.

V. **Successive induction:** An increased excitation of the agonist muscles follows stimulation (contraction) of their antagonists.

VI. **Reciprocal inhibition:** When a muscle contracts, there is simultaneous inhibition of its antagonist muscle.

VII. Successive induction and reciprocal inhibition is important for the coordinated action of the muscle and relaxation also. PNF is the concept of treatment for motor learning and *motor control* by using the untapped potential in the person with or without disability (Figure 4).[8]

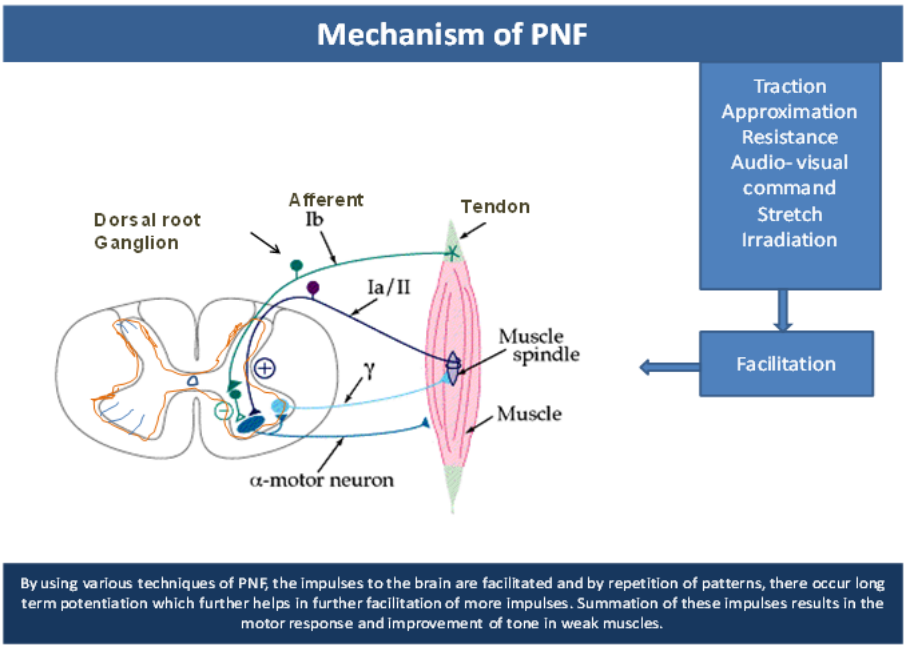

Figure 3 Mechanism of facilitation of nervous system by PNF.

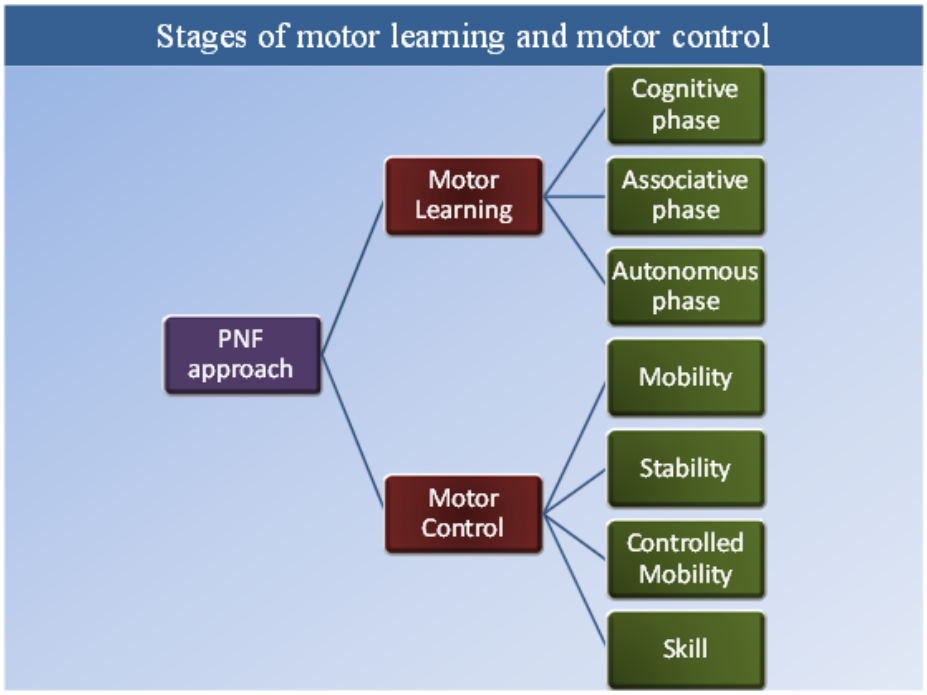

Figure 4 Stages of motor learning and motor control.

Stages of motor learning for PNF application

1. *Cognitive phase: what to do*
2. *Associative phase: How to do*

} *Audio – visual and tactile clue / facilitation*

3. *Autonomous phase : How to succeed* → *Repetition of movement until performed perfectly*

Stages of motor control: followed for PNF intervention in stroke

i. Mobility: Initiation of movement, random movement

ii. Stability: Static postural control

iii. Controlled mobility: mobility superimposed on previously developed static postural control by weight shifting within a posture

iv. Skill: Manipulation and exploration of the environment.[9]

Techniques of PNF application

The goal of the PNF techniques is to promote functional movement through facilitation, inhibition, strengthening, and relaxation of muscle groups by using concentric, eccentric, and static muscle contractions.[8,9] According to Sherrington, an impulse traveling down (the corticospinal tract) or traveling up (an afferent impulse) from peripheral receptors in the muscle causes an impulse volley that results in the discharge of a limited number of specific motor neurons, as well as the discharge of additional surrounding (anatomically close) motor neurons in the subliminal fringe area. An impulse causing the recruitment and discharge of additional motor neurons within the subliminal fringe is said to be facilitatory. Any stimulus that causes motor neurons to drop out of the discharge zone and away from the subliminal fringe is said to be inhibitory. Facilitation results in increased excitability and inhibition results in decreased excitability of motor neurons. Thus, the strengthening of weak muscles would be aided by facilitation, and muscle spasticity would be decreased by inhibition. Sherrington attributed the impulses transmitted from the peripheral stretch receptors via the afferent system as being the strongest influence on the alpha motor neurons. By following this principle, the therapist should be able to modify the input from the peripheral receptors and thus influence the excitability of the alpha motorneurons (Table 1).[10]

Table 1 Indications and uses of PNF techniques

Technique	Effects	Uses
Rhythmic initiation	Initiate movement	Paresis, hypokinesia
	Promote tone	Paralysis
	Increase range of motion	Decreased range of motion
	Increase coordination	In coordination
	Motor learning deficit	
	Communication deficit (Aphasia)	
Rhythmic rotation	Tone reduction	Increased tone/Spasticity Relaxation
Hold relax active movement	Initiate movement	Paresis
	Increase range of motion	Decreased range of motion
	Promote tone reduction	Muscle stiffness
Hold relax	Increase range of motion	Increased tone
	Relaxation	Relax tught muscle
Contract relax	Increase range of motion	Decreased range of motion
	Elongation of muscle	Decreased length in two joint muscle
Alternating isometrics/ Isotonic stabilizing reversals/Alternating holds	Increases	Proximal joint stability
	Stability	Trunk stability
	Strength	
	Endurance	
Rhythmic stabilization/ Isometric stabilizing reversals	Trunk Stability	Stroke

Table Continued...

Slow reversals/Reversal of antagonist/Dynamic reversals	Increases	Muscle weakness
	Strength	Decreased range of motion
	Range of motion	In coordination
	Coordination	
Slow reversal hold	Increase	
	Strength	Muscle weakness
	Balance	
	Endurance	Decreased endurance
Agonistic reversal	Functional stability	Decreased stability
	Strength	Decreased strength
Resisted progression	Strength	Promote locomotion
	Endurance	
	Normalize timing	
	Motor control	

Table 2 Patterns and techniques followed for PNF intervention in acute stroke

Parts of body	Techniques (T) and patterns (P) used	Effects
Neck	Flexion with rotation to the right	Increase neck stability
	Extension with rotation to the left	Improved trunk stability
	Flexion with rotation to the right	
	Extension with rotation to the left	
Trunk	Alternating isometrics (T)	Increases trunk stability
	Rhythmic stabilization(T)	Improved tone in Shoulder musculature
	Rhythmic initiation (T)	Strengthening of shoulder muscles
	Slow reversals(T)	Improved tone in muscles of extremities
Scapula and pelvis	Anterior elevation → D1- diagonal	
	Posterior depression↗	
	Posterior elevation → D2- diagonal	
	Anterior depression↗	
Upper extremity and lower extremity	Rhythmic initiation(T)	Improved strength in muscles
	Flexion-adduction-external rotation D1 Extension- abduction-internal rotation	Improved coordination Improvement in functional activities Improvement in gait
	Flexion- abduction- external rotation D2 Extension- adduction- internal rotation	

Rhythmic initiation (RI)

Voluntary relaxation, then passive movements progressing to active assisted and active resisted movements, to finally active movements. Verbal commands are utilized to set the speed and rhythm from the movements. Light tracking can be used during the resistive phase to facilitate movement.

Rhythmic stabilization (RS)

Utilizes alternating isometric contractions of first agonists, then antagonists against resistance; no motion is allowed.

Stabilizing reversals

Utilizes alternating isotonic contractions of first agonists, then antagonists against resistance, allowing only limited range of motion.

Hold relax (HR)

It's one of PNF Techniques usually performed in a position of comfort and below an amount that causes pain. Strong isometric contraction from the restricting muscles (antagonists) is resisted, then voluntary relaxation, and passive movement in to the newly gained selection of the agonist pattern.

Replication (hold relax active motion, HRA)

The individual is positioned in the shortened range/end position of the movement and is inspired to hold. The isometric contraction is resisted then voluntary relaxation and passive movement in to the lengthened range. The individual is then instructed to move into the end position; stretch and resistance are put on facilitate the isotonic contraction. For every repetition, increasing ROM is desired.

Dynamic reversals (slow reversals)

This technique utilizes isotonic contractions of first agonists and then antagonists performed against resistance. Contraction of stronger pattern is selected first with progression to weaker pattern. The limb is moved through full-range of motion.

Contract relax (CR)

It's one of PNF Techniques usually performed in a point of limited ROM within the agonist pattern. Strong, small range isotonic contraction from the restricting muscles (antagonists) with focus on the rotators is then an isometric hold. The contraction is held for 5-8 seconds and it is then followed by voluntary relaxation and movement in to the new range of the agonist pattern. Movement could be passive but active contraction is preferred.

Contract-relax-active-contraction (CRAC)

Active contraction in to the newly gained range serves to keep the inhibitory effects through reciprocal inhibition.

Resisted progression (RP)

Stretch, approximation and tracking resistance is used manually to facilitate pelvic motion and progression during locomotion; the amount of resistance is light in order to not disrupt the patient's momentum, coordination and velocity. RP may also be applied using rubber band resistance.

Rhythmic rotation (RRo)

Relaxation is achieved with slow, repeated rotation of the limb at a point where limitation is noticed. As muscles relax the limb is slowly and gently moved in to the range. As a new tension is felt, RRo is repeated. The individual can use active movements (voluntary efforts) for RRo or even the therapist can perform RRo passively. Voluntary relaxation whenever possible is important.

Mixture of isotonics (agonist reversals, AR)

Resisted concentric, contraction of agonist muscles moving with the range is then a stabilizing contraction (holding within the position) and then eccentric, lengthening contraction, moving slowing to the start position; there isn't any relaxation between the kinds of contractions. Typically used in antigravity activities/assumption of postures (i.e., bridging, sit to face transitions).

Rules for PNF application

i. Start intervention in cephalocaudal direction (Start from neck and trunk and progress towards extremities).

ii. First consider proximal then distal joints.

iii. Give intervention according to the stages of motor learning and motor control.

iv. Consider all muscles around a joint while intervention for example in paretic limb if you are giving intervention to agonist muscle, give equal intervention to antagonist also.

v. Teach reversible movements also e.g. If you are teaching sit to stand to stroke patient, also teach stand to sit that is equally important.

vi. Proceed according to the developmental stages e.g. teach turning by using anterior elevation of scapula and pelvis.

vii. Do not proceed to next stage until and unless patient learns one movement perfectly.

viii. Teach functional activities by using PNF e.g. donning and doffing, combing etc.

Studies of effects of PNF intervention in stroke

There are various techniques for stroke rehabilitation. But very few of them have been tried in acute stroke. Stroke rehabilitation should be started from the first day after stroke.

Study done by Morreale et al.[11] in ischemic stroke patients in early vs. late stage, that patients received early PNF treatment showed better improvement than late stroke after 12months.[9]

Study carried out by Chaturvedi et al.[12] in which PNF intervention was given to upper extremity for two weeks to the patients of acute stroke and there was significant improvement in the upper extremity function.[10]

Kim et al.[13] assessed functional reach test in two groups of stroke patients. One group was given PNF exercises for trunk and another group was given general exercises. PNF group showed significant improvement. They also noticed PNF group also showed improvement in activities in quadriceps and soleus in affected as well as non affected limb. This may be because of irradiation effect.[13]

According to Akosile et al.[14] PNF is the recommended treatment for functional ambulation in stroke patients. Kumar et al.[15] assessed gait parameters such as stride length, step length, gait, functional mobility etc. before and after the intervention of PNF exercises for pelvis. Control group was given resisted exercises, weight bearing exercises and bridging. They found the result that PNF group was significantly improved.[15]

PNF is one of the main concepts of rehabilitation for patients with neurological injuries, being used for several years. The trunk is the central region for motor control of lower and upper limbs and can irradiate to them. When an injury of nervous system occurs, as a stroke, this motor control can be disturbed and does not allow effective movements at limbs. Gontijo et al.[16] applied the PNF exercises for trunk to investigate the presence of irradiated dorsiflexion and plantar flexion the existing strength generated by them during application of PNF trunk motions. He found the result that most of the volunteers irradiated dorsiflexion while flexion and plantar flexion while extension pattern. He has concluded that PNF activates the distal muscle indirectly.[16]

Kumar et al.[15] also applied PNF rhythmic stabilization technique for knee that utilizes alternating isometric contractions of agonist and antagonist against resistance for 10 days. Lower limb performances were measured with Modified Emory Functional Ambulation Profile, Five Time Sit to Stand Test and Postural Assessment Scale For Stroke. There was significant improvement from baseline to after intervention.[17]

Wang et al.[18] investigated the immediate effects of PNF exercises on lower extremity of chronic stroke patients (after 6 months of stroke). He compared the stroke group with healthy controls. The tone of lower extremity muscle group was abnormally increased before the intervention. After the intervention there was decrease in the tone in the hypertonic muscles.[18]

Seo et al.[19] applied PNF exercises along with ramp gait training to chronic stroke patients (experimental group) and ground gait training to the control group and found the result that experimental group was improved more than control group.[19]

PNF intervention in acute stroke

The study was carried out in department of Neurology at Dr. Ram Manohar Lohia Institute of Medical Sciences, Lucknow (India). We recruited 120patients of acute stroke who were admitted to our department. Patients were divided into two groups. First group (Group. A) contained the patients admitted directly to our hospital after stroke and second group (Group B) consisted of the patients who were referred here from elsewhere after 2-3 weeks of stroke. Both groups were given PNF exercises for neck, trunk, scapula, pelvis, upper and lower extremity (proximal to distal). Patients with recurrent stroke, aphasia, >70years, fracture, cognitive impairment (MMSE<19), very severe stroke (NIHSS>21), pregnancy, multiple organ failure, amputation were excluded from the study (Figure 5).[20]

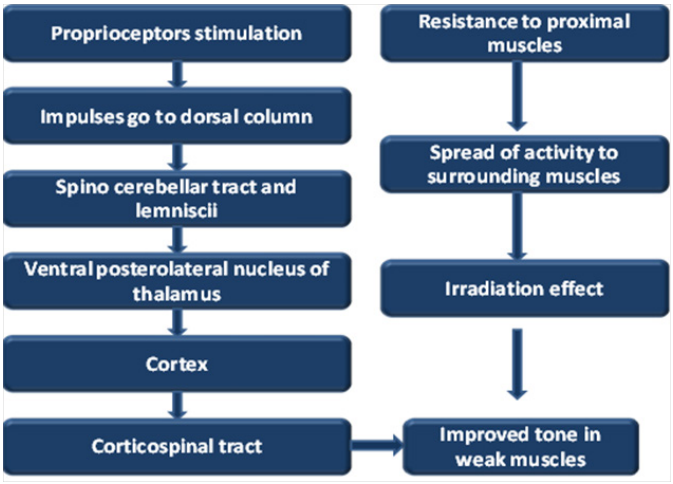

Figure 5 The possible mechanism involved in tone improvement after PNF intervention.

Assessment tools

i. National Institute of Health Stroke Scale (NIHSS): Stroke severity (0-42)

ii. Mini Mental State Exam (MMSE): Cognition (0-30)

iii. Barthel's- Index (BI): Activities of daily living (score 0-100)

iv. Fugl- Meyer assessment Scale (FMA): Sensory motor recovery (0-226)

v. Stroke specific quality of life: Quality of life after stroke (49-245)

Procedure

PNF exercises were started from neck, trunk, scapula and pelvis and finished at upper and lower extremity (Table 2). The intervention was given for 30minutes twice daily five days a week for four weeks (Figure 6).

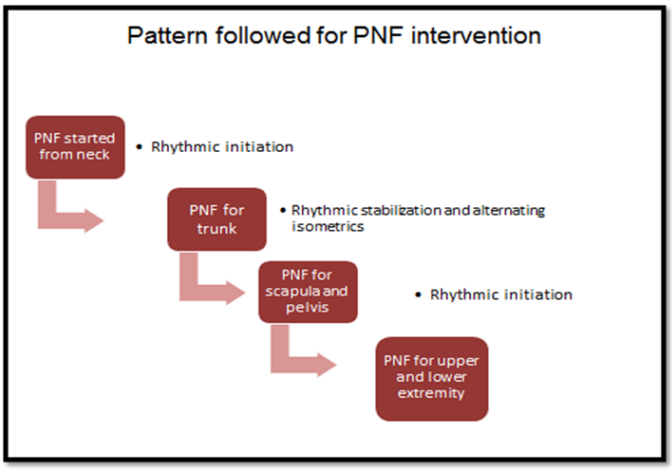

Figure 6 Direction of PNF intervention (cephalocaudal) and technique followed along with.

PNF for neck: Flexion with rotation to the left and extension with rotation to the right and vise-versa.

PNF for trunk: Rhythmic stabilization and alternating isometrics.

PNF for scapula and pelvis: Anterior elevation and posterior depression; posterior elevation and anterior depression by rhythmic initiation and repeated contraction.

For upper and lower extremity: D1 and D2 flexion and extension patterns

All the patients were followed up to 6months. There was significant improvement in Barthel's – Index scores at 4weeks (0.037) and 6months (0.005). Fugl-Meyer scores and Stroke Specific Quality of Life scores were more improved in group A. Although there was improvement in both groups after the intervention as compared to the scores assessed at the time of admission. The study shows that PNF intervention should be started as soon as possible. Improvement in tone and generation of voluntary control over the muscle improves functional ability. This leads to better quality of life. Improvement in the functional ability reduces hospital stay and burden of care givers also. In our study group A had hospital stay 21.3±4.6days and group B had 28.2±6.7days.

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Summary

PNF is a noninvasive approach of stroke rehabilitation. If the patient is able to follow the commands, PNF should be implemented from the first day after stroke. Improvement in functional activity will improve quality of life and better neuroplasticity. The studies regarding the PNF intervention in stroke are both conflicting and supportive, but they not been tried in acute stroke. Our results show that PNF is efficient in improving functional outcome after stroke.

Acknowledgments

None.

Conflicts of interest

Authors declare that there is no conflicts of interest.

References

1. Pandian JD, Sudhan P. Stroke epidemiology and stroke care services in India. *J Stroke*. 2013;15(3):128–134.
2. Pollock A, Baer GD, Langhorne P, et al. Physiotherapy treatment approaches for stroke. *Stroke*. 2008;39(2):519–520.
3. Knott M, Voss B. *Proprioceptive neuromuscular facilitation*. 2nd ed. England: Balleire, Daintily & Cogs; 1968.
4. Kabat H. Proprioceptive Facilitation in therapeutic exercise. In: Licht E, editor. *Therapeutic exercise*. 2nd ed. New Haven: E Licht; 1961.
5. Voss DE. Proprioceptive neuromuscular facilitation. *Am J PhysTher*. 1967;46(1):838–899.
6. Sullivan PE, Markos PD, Minor MAD. *An integrated approach to therapeutic exercise theory and clinical application*. Reston: Reston Publishing Company, Inc; 1982.
7. Guyner AJ. Proprioceptive Neuromuscular facilitation for vertebral joint conditions. In: Grieve GP, editor. *Modern manual therapy of the vertebral column*. London: Churchill Livingstone; 1986.
8. Adler S, Beckers D, Buck M. *PNF in practice: an illustrated guide*. Heidelberg: Springer Science & Business Media; 2007.
9. Martin ST, Kessler M. *Neurologic interventions for physical therapy*. Netherlands: Elsevier Health Sciences; 2015.
10. Prentice WE. Proprioceptive neuromuscular facilitation techniques in rehabilitation. *Techniques in musculoskeletal rehabilitation*. 1st ed. New York: McGraw-Hill Inc. 2001;97–213.
11. Morreale M, Marchione P, Pili A, et al. Early versus delayed rehabilitation treatment in hemiplegic patients with ischemic stroke: proprioceptive or cognitive approach. *Eur J PhysRehabil Med*. 2016;52(1):81–89.
12. Chaturvedi P, Singh AK, Kulshreshtha D, et al. Effects of Proprioceptive Neuromuscular Facilitation Exercises on Upper Extremity Function in the Patients with Acute Stroke. *Circulation: Cardiovascular Quality and Outcomes*. 2016;9(Suppl 2):A102– A102.
13. Kim Y, Kim E, Gong W. The effects of trunk stability exercise using PNF on the functional reach test and muscle activities of stroke patients. *J Phys Ther Sci*. 2011;23(5):699–702.
14. Akosile CO, Adegoke BA, Johnson OE, et al. Effects of Proprioceptive Neuromuscular Facilitation technique on the functional ambulation of stroke survivors. *Journal of Nigeria Society of Physiotherapy*. 2012;18(1-2):22–27.
15. Kumar S, Kumar A, Kaur J. Effect of PNF technique on gait parameters and functional mobility in hemiparetic patients. *Journal of Exercise Science and Physiotherapy*. 2012;8(2):67.

16. Gontijo LB, Pereira PD, Neves CD, et al. Evaluation of strength and irradiated movement pattern resulting from trunk motions of the proprioceptive neuromuscular facilitation. *Rehabilitation research and practice*. 2012:6.

17. Kumar S, Tiwari SP. Effect of PNF technique for knee muscles on lower limb performance in subacute stroke–an experimental study. *International Journal on Disability and Human Development*. 2016;15(1):37–42.

18. Wang JS, Lee SB, Moon SH. The immediate effect of PNF pattern on muscle tone and muscle stiffness in chronic stroke patient. *J Phys Ther Sci*. 2016;28(3):967–970.

19. Seo KC, Kim HA. The effects of ramp gait exercise with PNF on stroke patients' dynamic balance. *J Phys Ther Sci*. 2015;27(6):1747–1749.

20. Johnson GS, Johnson VS. The application of principles and procedures of PNF for the care of lumbar spine instabilities. *The journal of manual and manipulative therapy*. 2008;10(2):83–105.