EFFECTIVENESS OF THE PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION NECK PATTERN TRAINING ON TRUNK BALANCE IN THE STROKE PATIENTS – A RANDOMIZED CONTROLLED TRIAL

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Abstract

Background: Stroke is the fourth leading cause of death and the fifth leading cause of disability in India. There is bilateral involvement of trunk muscles in stroke patients contrary to limb muscles. Alteration of trunk muscles position sense and its weakness has a major impact on balance. Promising evidence suggests that the PNF-neck pattern has played a crucial role in enhancing proprioceptive feedback to trunk muscles. Extensive research in this field is warranted.

Aim of the study: Was to investigate the effectiveness of neck diagonal pattern PNF training on improving trunk balance measured by trunk impairment scale (TIS) in sub-acute stroke patients.

Methods: A randomized controlled trial was conducted in 56 stroke patients with the onset of the condition between 3 to 9 months. They were randomly assigned to either a (i) PNF neck pattern group where regular physical therapy and neck PNF pattern training were given and (ii) a regular physical therapy group alone for which only a conventional physical therapy program was carried out. The training was given for 6 weeks, 3 sessions in a week. The treatment effectiveness was investigated by the improvement in TIS.

Results: The mean baseline TIS for the PNF training group was 15.35 ± 0.89 and it improved significantly to 19.92±0.89 after the completion of training, $z = 4.61$, $p = 0.001 < 0.05$. The mean pre-TIS for the regular physical therapy group was 15.29 ± 1.12 and it was improved significantly to 17.25 ± 1.39 following the course of training, $z = 4.35$, $P = 0.001 < 0.05$. Between-group comparison shows that PNF training is significantly better than regular physiotherapy training in improving trunk balance in acute stroke patients, the mean difference in TIS between the two groups was 2.65 ± 1.14.

Conclusion: It is concluded that PNF – the diagonal neck pattern is effective in improving the trunk balance of sub-acute stroke patients measured by the trunk impairment scale.

Keywords: Stroke, PNF – neck pattern, balance, trunk control, proprioception.

Introduction

Stroke is a grave public health problem. The global Burden of Disease (GBD) study in its recent updates has quoted that there has been a rise of 26 percent in global stroke death in the past two decades.[1] The important estimate from GBD is that most of the global burden of stroke was carried by low- and middle-income countries (LMICs).[1] India has been undergoing tremendous changes concerning its demographic, economic, and epidemiological background. This has contributed to an increase in the life expectancy of the aged population.[2] In India stroke is the fourth leading cause of death and the fifth leading cause of disability.[3] The link between high life expectancy and disability in stroke survivors has crippled their quality of life and functional status. Stroke leads to unilateral upper and lower limb weakness or paralysis. On the contrary, it affects bilateral trunk muscles resulting in the weakness of trunk muscles on both sides. It has been identified that alteration of trunk muscle position sense and its weakness has a major impact on balance difficulty in stroke patients.[4] Anticipatory postural adjustments of trunk muscles are crucial in reaching tasks by providing proximal stabilization.[5] Recent literature supports that walking ability and balance in stroke patients are by and large influenced by trunk performance.[6] Therefore physical therapy strategies addressing trunk muscles in stroke patients is need of hour. A more novel approach in this regard is highly sought. The pre-requisite for good trunk stability is adequate trunk muscle strength and flexibility, neural control, and proprioception.[7] The awareness of movement mediated by mechano sensory neurons in muscles, tendons, and joints is called proprioception.[8] It is of paramount importance to regain trunk control to generate the trunk balance during the post-stroke period. Proprioceptive neuromuscular facilitation (PNR) is a promising form of physical therapy intervention in gaining trunk stability. It is a neurophysiological approach where peripheral impulses are facilitated to the central nervous system by the stimulation of sensory receptors present in the muscles and joints by stretch and resistance.[9] By the effective activation of proprioceptors in a muscle and tendon, it is demonstrated that muscle strength, flexibility, balance, and overall functions have improved in stroke patients.[10] It has been documented that the neck pattern has been shown to enhance the stability of the head and neck in stroke patients.[11] The PNF approach combines functional movements in diagonal patterns with techniques of neuromuscular facilitation to generate motor responses and enhance neuromuscular control and function. Resistance applied to the stronger muscle group in a diagonal pattern facilitates the response of the weaker muscle group.[12] Efficient application of resistance contributing irradiation.[13] It is the spread of response. Resistance to neck motion has demonstrated irradiation to the trunk muscles. Optimal head control and adequate mobility and positioning of the cervical spine are necessary for almost all activities. PNF neck pattern is more suited for this. PNF neck pattern is shown to enhance trunk motions, and achieves, stability of the head and neck, and resistance to neck motion provides irradiation to trunk muscles.[14] Even though the existing studies have shown that neck muscle control plays an important role in enhancing trunk balance in stroke patients.[15,16] There is a gap in the well-made studies investigating the influence of diagonal neck pattern PNF on trunk performance in stroke patients. Therefore, the present study aimed to investigate the effectiveness of the PNF neck diagonal pattern on the improvements in the trunk balance measured by TIS in sub-acute stroke patients.

Methods

Participants: Fifty-six stroke patients were selected based on the selection criteria. The study purpose and methods were clearly explained to the patients in their regional language and clarified any concerns.

Inclusion Criteria

· Patients with first episode of stroke confirmed by either computed tomography (CT) scan or magnetic resonance imaging (MRI).
· Age of stroke between 30 to 60 years.
· Both genders were selected.
· Duration of stroke between 3 to 9 months.
· Neck muscle power of at least 3 in manual muscle testing.
· Patient can able to sit and stand independently.

Exclusion Criteria

· Stroke patients associated with uncontrolled hypertension and significant cardiovascular problems.
· Musculoskeletal problems like fractures, orthopedic surgeries, spinal deformities, and chronic neck pain.
· Patients associated with the sense of depression and anxiety.

Ethical Clearance

The institutional ethics committee of Santhosh College of Physiotherapy, Madurai, Tamil Nadu has approved the study. The certification number is L.E.C. No. 21/2019.

Informed Consent

Written informed consent was obtained from each participant at the beginning of the study before randomization. It is on par with the Declaration of Helsinki.

Sample size estimation

Sample size was calculated based on the suitable sample size formula appropriate for Randomized Controlled Trial (RCT) – superiority trials.

$$N = 2 \times \left(\frac{\propto + \beta}{\delta} \right) \times S^2$$

Where N = number of participants in each group

$\propto$ = level of significance

β = power

δ = clinically significant difference

S = standard deviation

The level of significance was fixed as 95% which is equal to 1.96. The power was chosen as 80% with the corresponding value of 0.845, The standard deviation (S) was 2.25 for the trunk impairment scale observed from the previous studies of a similar nature. The clinically meaningful difference, d = 2.5 inferred from previous literature. The dropout rate was 20%. Therefore, the obtained sample size was 28 in each group.

Study Design

The current study design was RCT – parallel group design – superiority trial with an allocation ratio of 1:1.

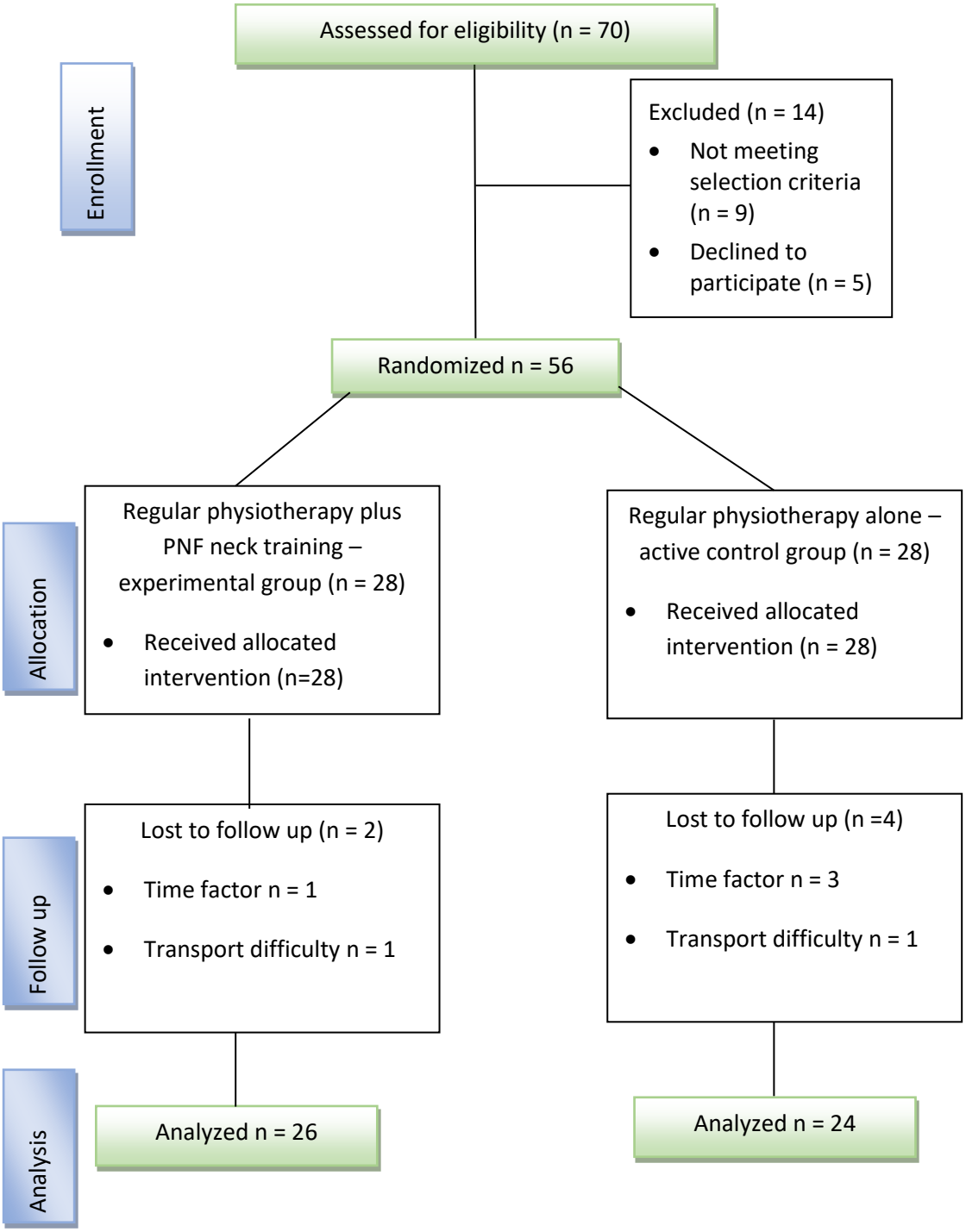
Study Setting

The study was carried out in the outpatient department of Santhosh College of Physiotherapy, Madurai, Tamil Nadu, India.

Group Allocation and Concealment

The patient was assigned to each group by block randomization method. The block size was fixed as four and hence by six sequences allocation was performed. The allocation was carried out by the research assistant who was blinded by the study methods and procedure.

Allocation flow diagram



Study Procedure

The patients were randomly divided into two groups (viz. (i) Group – 'A' – experimental group, for them proprioceptive neuromuscular facilitation (PNF) diagonal neck pattern, was trained along with the regular physiotherapy training. (ii) group 'B'- an active control group, for regular physiotherapy training was alone given. The training was given for 6 weeks, 3 times per day. The experimental group received 30 minutes of regular physiotherapy training plus 20 minutes of PNF training whereas the control group received 50 minutes of regular physiotherapy training. The trunk balance was evaluated by the Trunk Impairment Scale (TIS) at the beginning of the study before the commencement of the training and again on the succeeding day of the completion of the entire treatment sessions. TIS was evaluated by an experienced physiotherapist who had more than 20 years of practice in the evaluation of balance and motor function in stroke patients. The evaluator was blinded by the study groups.

Interventions

(i) **PNF diagonal neck pattern**[17]

PNF training was administered in both neck flexion and extension pattern. The patients were sat on a mat with knee height and their feet were placed firmly on the ground with shoulder width apart with hands on their knees.

Neck Flexion Pattern[17]

Preparatory Position

The experimenter stood behind the patient on the right side with the top of his right finger placed below the patient's chin. The experimenter placed his left hand on the left of the top of the patient's head in a diagonal direction. The patient's chin was pulled by the experimenter so that it was lifted and the neck assumed an extended position. In this position, the patient's head was tilted and rotated towards the right side. The preliminary exercise was performed with sufficient explanation and therefore patient was able to recognize and predict the exercise direction precisely.

PNF training Phase

At this point, the PNF training phase started. Patients were instructed to 'pull their chin in' and 'look at their left hip'. After the instructions, the patient's head, neck, and upper thoracic spine had sufficient extension, left rotation, and left lateral flexion. The experimenter provided resistance against left rotation, flexion, and lateral flexion by providing traction to the patient's chin. The identical method was performed on the opposite side.

Neck Extension Pattern[17]

Preparatory Position

The preparatory position was the same as in the neck flexion pattern described above. The experiment stood behind the patient on the right side. He placed his right thumb on the right side of the patient's chin with his left hand on the right of the top of the patient's head in a diagonal direction. The preparatory position was the neck in flexion, head was rotated and tilted to the left.

PNF training phase

The experimenter had instructed the patients to "lift their chin" and then "lift their head to look above.' The assumed final position of the patient's spine was head, neck, and upper thoracic spine had complete extension, right rotation, and right lateral flexion. Resistance

against right rotation, extension, and lateral flexion was provided during the exercise to induce strong muscle contraction. The identical method was performed on the opposite side.

(ii) Regular Physiotherapy Training[18]

It consisted of strengthening exercises of upper and lower extremity and trunk muscles, range of motion exercises, and stretching. The specified exercise given was pelvic bridging, rolling, sitting, and standing exercises, walking practice, balancing in parallel bars and wobble board exercises, reacting activities, and functional tasks training.

Trunk Impairment Scale (TIS)[19,20]

It has three subscales including static and dynamic sitting balance and coordination. Each subscale consisted of 3 to 10 items. The minimum score was 'o' and the maximum score was 23. Three attempts were given for each item and the best performance was taken as the final score. The static subscales investigated the (i) ability of the patient to maintain a sitting position with feet supported (ii) the ability to maintain a sitting position when the legs were passively crossed and (iii) the ability to maintain a sitting position when the patient crossed the legs actively. The dynamic subscale contained items on lateral trunk flexion and unilateral lifting of the hip. Coordination sub-scales were investigated by instructing the patient to rotate the upper or lower part of the trunk 6 times initiating the movements either from the shoulder girdle or from the pelvic girdle. For each item, a 2, 3 – or 4 – point ordinal scale was used.

Statistical Analysis

Basic characteristics of the study patients such as age and duration of stroke were compared between groups by independent sample 't' test. Gender and type of stroke between groups were analyzed by the Mann-Whitney 'U' test. Site of stroke comparison was done by chi-square test of association. Within the group pre-post comparison of TIS was performed by Wilcoxon's signed rank test as the distribution was non-normal, checked by Shapiro–Wilk test of normality. The magnitude of improvement in TIS between groups was studied by the Mann-Whitney 'U' test as the distribution violates the test of normality.

Results

The basic characters of the study patients are shown in Table – 1.

Table – 1: Basic Characters of the Study Patients

Characters	A		B		Total		$t/z/u^2$	P
Age (M, S.D.)	51.27	7.65	51.71	6.44	51.48	7.03	0.22	0.828
Duration (M, S.D.)	7.62	1.06	7.79	0.98	7.70	1.02	0.61	0.545
Gender (N, %)								
Male	22	84.6	19	79.2	41	82	0.49	0.620
Female	4	15.4	5	20.8	9	18		
Site (N, %)								
M.C.A.	2	7.7	2	8.3	4	8	46.99	0.025*
A.C.A.	3	11.5	2	8.3	5	10		
P.C.A.	10	38.5	8	33.3	18	36		
Vertebrobasilar infraction	2	7.7	2	8.3	4	8		
Cerebellar infraction	5	19.2	5	20.8	10	20		

Lacunar infraction	1	3.8	2	8.3	3	6		
More than one site	3	11.5	3	12.5	6	12		
Type of stroke (N, %)								
Ischemic	22	84.6	18	75	40	80	0.84	0.401
Hemorrhagic	4	15.4	6	25	10	20		

M – mean, S.D. – standard deviation, t – independent sample test, z – Mann – Whitney 'U' test, x^2 – chi-square test, p – probability, * - significant, M.C.A. – middle cerebral artery, A.C.A. – anterior cerebral artery, P.C.A. – posterior cerebral artery, N – number, % - percentage.

The two groups were homogenous with respect to age, duration of condition, gender, site and types of stroke. There was significant improvement in the TIS after therapy in both the groups as shown in Table – 2.

Table – 2: Trunk impairment scale – within group comparison

Trunk Impairment Scale	Shapiro – Wilk		M	S.D.	Test-statistics	
	Value	P			Z	P
Group A						
Pre	0.86	0.003*	15.35	1.13	4.61	0.001*
Post	0.85	0.002*	19.92	0.89		
Group B						
Pre	0.85	0.002*	15.29	1.12	4.35	0.001*
Post	0.89	0.017*	17.25	1.39		

M – mean, S.D. – standard deviation, z – Wilcoxon's signed rank test, P – probability, * - significant.

The mean improvement in TIS was significantly higher in PNF group, M = 4.58 ± 0.58 than in regular physiotherapy alone group, M = 1.96 ± 0.75, P = 0.001 < 0.05 as shown in Table.3.

Table – 3: Trunk impairment score – between group comparison

Trunk Impairment	Shapiro-Wilk		M.D.	Test Statistics	
	Value	P		Z	P
A	0.68	0.001*	4.58 ± 0.58	6.17	0.001*
B	0.81	0.001*	1.96 ± 0.75		

M.D. – mean difference, Z – Mann – Whitney 'U' test, P – probability, * - significant.

Discussion

The current study results showed that trunk balance was improved in both the PNF–diagonal neck pattern training group as well as in the routine physical therapy group. However, between-group comparison revealed that there was a significantly higher improvement in trunk balance measured by TIS in the PNF training group when compared to the routine physical therapy group. The mean improvement in TIS was 4.88 ± 0.58 in the PNF diagonal neck pattern

group whereas it was only 1.96 ± 0.75 in the routine physical therapy group. The difference in the improvement was on average 2.62 higher in the PNF training group, suggesting that the difference was not only statistically significant but also a clinically significant improvement. The mean difference in the improvement of TIS after PNF neck pattern training in the present study has correlated well with the study done by Dinesh M et al demonstrated a mean of 2.01 higher improvement in the PNF neck pattern group compared to controls.[21] The mean improvement of TIS in the present study following PNF training is correlated well with the study done by Hwangbo PN et al demonstrated a mean improvement of 4.5 ± 3.4 following PNF neck pattern in stroke patients.[17] The baseline TIS in the present study was m = 15.32 ± 1.12 which was comparatively more than the study by Dinesh M et al identified a baseline TIS of m = 13.52 ± 1.13.21 The mean duration of condition in the present work was 7.70 ± 1.02 months whereas most of the patients in the study by Dinesh M et al had acute onset of stroke (80%). This could have been the difference in the baseline TIS between the present work and the study by Dinesh M et al.[21] Further it is identified in previous literature that baseline motor function and trunk balance are by and large influenced by the severity of stroke decided by infarction size, the time of admission from the occurrence, and gross area of involvement.

Mesaniya TM et al, have analyzed the previous literature evaluating the effectiveness of PNF neck pattern in improving trunk balance in stroke patients.[22] The author analyzed the six moderate to high-quality studies and found that the PNF neck pattern is an effective exercise program for improving trunk control, enhancing coordination of arms and legs, and improving walking ability and balance in stroke patients. In the present work, TIS was selected to identify the improvements in trunk balance following therapy. This scale consisted of three components viz. (i) static sitting balance (ii) dynamic sitting balance and (iii) coordination. Hence it is evident that PNF training – neck diagonal pattern has a significant positive influence on sitting balance and coordination. Future works evaluating the influence of training on other measures of balance are highly sought. The superiority of the PNF neck pattern in improving trunk balance is based on the stimulation of proprioceptive impulses of the neck muscles which has been shown to produce greater reflex feedback to trunk muscles causing enhancement of its strength and flexibility. The neck muscles have high proprioception receptors compared to other muscles in the body and play a significant role in maintaining posture and walking. It is suggested to carry out future work testing the effectiveness of PNF neck pattern on the other components such as gait parameters, walking ability, and lower limb muscle strength in stroke patients. It is also recommended to investigate the effectiveness of PNF neck patterns in the different stages of stroke patients.

Conclusion

It is concluded that PNF – diagonal neck pattern is an effective physical therapy approach in improving trunk balance measured by trunk impairment scale in patients with sub-acute stroke patients. It is suggested to carry out a well-made study on the influence of this training on walking parameters and lower limb strength in stroke patients. It is also recommended to investigate this approach in the different stages of stroke patients.

References

1. GBD 2019 Stroke Collaborators. Global, regional, and national burden of stroke and its risk factors, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet Neurol. 2021 Oct;20(10):795-820. doi: 10.1016/S1474-4422(21)00252-0. Epub 2021 Sep 3. PMID: 34487721; PMCID: PMC8443449.
2. Horton R, Das P. Indian health: the path from crisis to progress. Lancet. 2011 Jan 15;377(9761):181-3. doi: 10.1016/S0140-6736(10)62179-4. Epub 2011 Jan 10. PMID: 21227502.
3. Jones SP, Baqai K, Clegg A, Georgiou R, Harris C, Holland EJ, Kalkonde Y, Lightbody CE, Maulik PK, Srivastava PM, Pandian JD, Kulsum P, Sylaja PN, Watkins CL, Hackett ML. Stroke in India: A systematic review of the incidence, prevalence, and case fatality. Int J Stroke. 2022 Feb;17(2):132-140. doi: 10.1177/17474930211027834. Epub 2021 Jul 2. PMID: 34114912; PMCID: PMC8821978.
4. Ryerson S, Byl NN, Brown DA, Wong RA, Hidler JM. Altered trunk position sense and its relation to balance functions in people post-stroke. J Neurol Phys Ther. 2008 Mar;32(1):14-20. doi: 10.1097/NPT.0b013e3181660f0c. PMID: 18463551.
5. Moore S, Brunt D. Effects of trunk support and target distance on postural adjustments prior to a rapid reaching task by seated subjects. Arch Phys Med Rehabil. 1991 Aug;72(9):638-41. PMID: 1859256.
6. Verheyden G, Vereeck L, Truijen S, Troch M, Herregodts I, Lafosse C, Nieuwboer A, De Weerdt W. Trunk performance after stroke and the relationship with balance, gait and functional ability. Clin Rehabil. 2006 May;20(5):451-8. doi: 10.1191/0269215505cr955oa. PMID: 16774097.
7. Klein DA, Stone WJ, Phillips WT, Gangi J, Hartman S. PNF training and physical function in assisted-living older adults. Journal of aging and physical activity. 2002 Oct 1;10(4):476-88.
8. Tuthill JC, Azim E. Proprioception. Curr Biol. 2018 Mar 5;28(5):R194-R203. doi: 10.1016/j.cub.2018.01.064. PMID: 29510103.
9. Chaturvedi P, Singh AK, Kulshreshtha D, Thacker AK. PNF in acute stroke. MOJ Anat & Physiol. 2018;5(6):391-9.
10. Klein DA, Stone WJ, Phillips WT, Gangi J, Hartman S. PNF training and physical function in assisted-living older adults. Journal of aging and physical activity. 2002 Oct 1;10(4):476-88.
11. Don Kim K, Lee HJ, Lee MH, Ryu HJ. Effects of neck exercises on swallowing function of patients with stroke. J Phys Ther Sci. 2015 Apr;27(4):1005-8. doi: 10.1589/jpts.27.1005. Epub 2015 Apr 30. PMID: 25995543; PMCID: PMC4433964.
12. Carolyn Kisner and Lynn Allen Colby. Therapeutic exercises: Foundations and techniques, fifth edition; Davis Company, 2007 Chapter 6 and 8, pg. 251-269, 195-202.
13. Susan S. Adler, Dominiek Beckers, Math Buck: PNF in Practice; An Illustrated Guide. Third edition. Springer, 2008, chapter 1,2 and 9, pg. 1-18,155-168.
14. Adler SS, Beckers D, Buck M. PNF in Practice [electronic resource]: An Illustrated Guide.
15. Boyd-Clark LC, Briggs CA, Galea MP. Muscle spindle distribution, morphology, and density in longus colli and multifidus muscles of the cervical spine. Spine (Phila Pa 1976). 2002 Apr 1;27(7):694-701. doi: 10.1097/00007632-200204010-00005. PMID: 11923661.

16. Kim GM, Oh DW. Neck proprioceptive training for balance function in patients with chronic poststroke hemiparesis: a case series. J Phys Ther Sci. 2014 Oct;26(10):1657-9. doi: 10.1589/jpts.26.1657. Epub 2014 Oct 28. PMID: 25364136; PMCID: PMC4210421.
17. Hwangbo PN, Don Kim K. Effects of proprioceptive neuromuscular facilitation neck pattern exercise on the ability to control the trunk and maintain balance in chronic stroke patients. J Phys Ther Sci. 2016 Mar;28(3):850-3. doi: 10.1589/jpts.28.850. Epub 2016 Mar 31. PMID: 27134370; PMCID: PMC4842451.
18. Asghar M, Fatima A, Warner S, Khan MH, Ahmad A, Siddique K. Effectiveness of proprioceptive neuromuscular facilitation on balance in chronic stroke patients. Rawal Medical Journal. 2021 Mar 19;46(1):212-.
19. Verheyden G, Nieuwboer A, Mertin J, Preger R, Kiekens C, De Weerdt W. The Trunk Impairment Scale: a new tool to measure motor impairment of the trunk after stroke. Clin Rehabil. 2004 May;18(3):326-34. doi: 10.1191/0269215504cr733oa. PMID: 15137564.
20. Verheyden G, Nieuwboer A, Van de Winckel A, De Weerdt W. Clinical tools to measure trunk performance after stroke: a systematic review of the literature. Clin Rehabil. 2007 May;21(5):387-94. doi: 10.1177/0269215507074055. PMID: 17613559.
21. Dinesh M, Thenmozhi P, KalaBarathi S. Proprioceptive Neuromuscular Facilitation Neck Pattern and Trunk Specific Exercise on Trunk Control and Balance-an Experimental Study. Int J Ther Massage Bodywork. 2022 Dec 1;15(4):9-17. doi: 10.3822/ijtmb.v15i4.727. PMID: 36467307; PMCID: PMC9683997.
22. Mesaniya TM, Sutaria J. Effect of proprioceptive neuromuscular facilitation neck pattern exercises on balance in stroke - an evidence-based study. International Journal of Science & Healthcare Research. 2021; 6(3): 48-53. DOI: https://doi.org/10. 52403/ijshr.20210709.