(International Print/Online Journal)

SJIF IMPACT FACTOR: 6.829
PUBMED-National Library of Medicine ID-101739732

ISSN (Print): 2209-2870
ISSN (Online): 2209-2862

International Journal of Medical Science and Current Research (IJMSCR)
Available online at: www.ijmscr.com
Volume 9, Issue 2 , Page No: 163-178
March-April 2026

IJMSCR

Comparison Between The Effect Of Rhythmic Stabilization Vs Stabilizing Reversal On Knee Muscle Power, Proprioception And Balance In Geriatric Population: Interventional Study

[1]Dr. Isha Rajesh Berde, [2]Dr. Shamla Pazare,
[1]MPT Neurophysiotherapy, [2]H.O.D Neuro Department,
[1,2]CMF College of Physiotherapy, Pune.

***Corresponding Author:**
Dr. Isha Rajesh Berde
MPT Neurophysiotherapy, CMF College of Physiotherapy, Pune.

Type of Publication: Original Research Paper
Conflicts of Interest: Nil

Abstract

The increased risk of falling in the geriatric population is mostly owing to older person's difficulty in maintaining balance when performing ADLs. Proprioceptive Neuromuscular Facilitation consists of strength, flexibility, co-ordination components which could lead to significant improvement in balance, isometric strength and several functional tasks in this population. Therefore, we wanted to study the effect of Rhythmic Stabilization and Stabilizing Reversals technique of PNF on knee muscle power, proprioception and balance in geriatric population. A total 52 subjects were selected in our study after they met the inclusion criteria, from which they were randomly divided into two groups where group A received Rhythmic Stabilization and B received Stabilizing Reversals for 4 weeks, thrice in a week. Knee proprioception using goniometer pro application, muscle power using 4 step stairs climb power test and balance using MiniBESTEST scale was measured pre and post intervention. The results of the study showed that there was significant difference in pre and post values of knee muscle power ($p < 0.01$), proprioception ($p < 0.01$) and MiniBESTEST ($p < 0.01$) of both the groups. On comparison of the two groups, there was significant difference in knee muscle power ($p<0.01$), proprioception ($p<0.01$) and MiniBESTEST($p<0.01$) outcome measures. Hence, we concluded that Stabilizing Reversals is effective in improving knee muscle power, knee proprioception and balance in geriatric population in comparison to Rhythmic Stabilization.

Keywords: Geriatric Population, Balance, PNF, Stabilizing Reversals, Knee Proprioception, Muscle Power

Introduction

There has been rise from 1 billion (2020) to 1.4 billion of geriatric population in the world, where by 2030 every 1 of 6 person in this world will be above 60 years of age (World Health Organization). With the rise in percentage of elderly population, there occurs simultaneous rise in various government related policies and government-initiated strategies to aid the geriatric population in various countries. Our field of rehabilitation also works in close proximity with the geriatric population, where a physical therapist faces challenge while providing physiotherapy to this older population as the caseloads are usually very mixed.

Ageing in human alludes to multidirectional interaction of physical, mental and social changes. (1) Aging is subjected to longitudinal processes as a consequence of physiological changes, such as a higher level of stress, mitochondrial dysfunction, abnormality of inflammatory processes, decreased hormone production, and decreased metabolic rate which can lead to catabolism and degeneration of organs. (2,3) These processes lead to a progressive

loss of nerve extensions, bone mass, skeletal muscle mass, and strength. As ageing progresses it leads to gradual decrease in neuromuscular control as well as changes in joints and other structures altering the ability to execute smooth accurate and controlled motor responses. (4) Physiological changes associated with ageing are reduction in muscle strength (5) joint ROM and reaction time. (6) Body undergoes changes as the age advances, particularly those related to the balance, this starts around the age of 45 years and not only affects the sensory system like visual, vestibular and somatosensory but also physical characteristics like flexibility, strength, balance and co-ordination. Individuals rely primarily on proprioceptive and cutaneous input to maintain a typical quiet stance, but as task complexity rises, they must integrate information from different sensory systems. (7, 8) According to Brocklehurst et al. 1978, Iskrant 1968, Overstall et al. 1977, there was an increased incidence of falls in the elderly which was correlated with loss of proprioception, as they required a longer time when compared to younger people to carry out movements and they failed to adjust their movements to compensate for errors. (9,11) At present, proprioception can be defined as the cumulative neural input to central nervous system from specialized nerve endings called mechanoreceptors, which are located in joint capsules, ligaments, muscles, tendons and skin. (12) Proprioception is fundamental for generating smooth and coordinated movements, it also aids in maintenance of normal body posture, regulation of balance and postural control along with motor learning & relearning. (13,14) Proprioception decreases with advancing age due to the underlying changes in the function of muscle spindle and in addition it leads to deficits in processing of sensory inputs (myelin abnormalities, axonal atrophy and declined nerve conduction velocity) (15-17). There are studies which prove that there is decline in knee proprioception as ageing takes place.

(18) Some studies have found that proprioception which has diminished with age, regular activity may help in attenuating this decline, but there is a strategy to reduce this incidence of fall and poor proprioception associated with ageing, which is doing regular exercises. Among several exercise protocols that have been shown to reduce the risk of falls in this population, proprioceptive neuromuscular facilitation (PNF) is particularly compelling, as exercise programs aim to improve balance in the elderly must involve coordination and proprioception activities in addition to strengthening (4). According to the study done by Jonathan F (2003) they identified that muscle power was more influential proximal determinant of physical performance than impairments in strength and also emphasized that muscle power was an important determinant of mobility skills in older adults. (19) Some studies have indicated that PNF exercises are able to improve muscle strength and balance in the elderly. (20) as this approach of therapeutic exercises uses specific diagonal movement patterns, reproducing functional movements such as gait, to improve muscle strength and flexibility. PNF is a type of rehabilitation technique where multiple sensory stimulation techniques are used that summate to improve functional outcomes of the patient. It is a concept of treatment for motor learning and control (21) which works by stimulation of muscle and joint proprioceptors (22) using its principles of tactile stimulation, visual stimulation, resistance, traction, temporal and spatial summation, manual contact, body position and body mechanics, auditory stimulation via commands, patterns and timing. PNF therapy implies a multifaceted therapeutic approach emphasizing the essence of motor control as determinant of optimal function restoration. Also, when treating the subjects with PNF concept its essential to develop appropriate motor strategies, a positive approach with minimal physical pain, attainment of tasks and use of subjects physical and mental resources and to maintain motivation for further activity. (23,24) Older population frequently show a reduced ability to adjust the speed of contractions in response to activity demands. PNF's patterns and approaches provide a complete framework for strength and speed testing and retraining. The PNF techniques necessitate functional combinations of muscular activities, allowing each one to function in a variety of capacities (e.g., primary mover, stabilizer, etc.) The inadequate control of the speed or strength of reciprocal motion, can lead to altered arthrokinematics and development of compensatory movement pattern, (25) which is also observed in the older population (Claudia M, 2004). The techniques of PNF named Reversals of Antagonists works to bring this co-ordination between the agonistic and antagonistic muscle group which is reduced in the geriatric population. Stabilizing reversal technique and Rhythmic stabilization

Volume 9, Issue 2; March-April 2026; Page No 163-178

technique of PNF are based on Sherrington's principle of successive induction. Stabilizing reversal (SR) is one of the techniques of PNF, this alternating technique works on the synergistic and antagonist synergies, which are aimed at promotion of the coordination of the main muscle and antagonist muscles (Koo et al, 2009) and in Rhythmic Stabilization (Rhythmic Stabilization, RS) technique there is co-contraction of agonist & antagonists, as a technique to make this happen, no movement shall occur.

There is an alternate isometric contraction in response to resistance in Rhythmic Stabilization technique of PNF (Adler et al, 2008).

Stabilizing Reversals is defined as alternating static contractions opposed by enough resistance to facilitate stability in a specific position with changing manual contact. Stabilizing Reversals is characterized by alternating isotonic contractions opposed by enough resistance to prevent any motion, where the therapist gives dynamic command and allows only a very small motion. Rhythmic stabilization is defined as alternating isometric contractions against resistance without relaxation and without change of manual contacts. Rhythmic stabilization is characterized by alternating isometric contractions against resistance where no motion is intended. This technique works on the goals to increase active as well as passive range of motion, increase stability by incorporating co-contraction, maintaining a position, increase strength, increase stability and balance. Both the techniques have their due share in increasing strength, coordination and proprioception.

Studies have also shown that Stabilizing Reversal and Rhythmic Stabilization of PNF in subjects with stroke is effective and improves the lower limb performance. These PNF Techniques improve the strength of the leg as well as work to improve the balance has been reported by many previous studies. (26) A study conducted by Jae-Wook Shin·Seung-Min Lee·Jwa-Jun Kim, proves that Stabilizing Reversal and Rhythmic Stabilization Techniques of PNF does have a positive impact on improving Static Balance in Normal Adults. (27) Therefore, we would like to find out whether in geriatrics similar results can be obtained.

Also, we would like to find out if there is any significant change in knee muscle power, proprioception and balance in geriatrics population using similar technique. Hence the aim of our study is to study and compare the effects of 4 weeks of Rhythmic Stabilization and Stabilizing Reversal on knee muscle power using 4 Step Stair Climb Power test, on knee proprioception using Goniometer Pro application and balance using MiniBESTEST in geriatric population.

Methodology : The present experimental study was conducted on 52 subjects of geriatric population. Ethical approval for the study was given by the ethics committee. After screening the participants, an informed consent was taken from al,l for the voluntary willingness of the subjects to take part in the study. Further all the subjects were assessed using the screening tools to see if they meet the inclusion criteria. The inclusion criteria for the study was; 1) Elderly population between age of 60 to 75 years of age, 2) Both male and female, 3)Ability to walk without assistance upto minimal 10 meter, 4) Criteria for TUGG < 26), whereas the exclusion criteria was People with uncontrolled diabetes mellitus, uncontrolled hypertension, Any previous History of fall, Obesity (BMI greater than 25 kg/m2). Then participants were distributed into group A and group B by simple randomized sealed enveloped method. Brief demographic assessment including the subject's height and weight was taken. PRE and POST treatment session (4 week) MiniBESTest, 4 step stair climb power test and joint position sense of knee was taken. The session consisted of PNF training for 30 mins, 3 times a week, for total 4 weeks. Conventional exercises were given to the subjects of both the groups, which began with 1. slow walking for 5 minutes as technique of warm up, 2. Static manual stretching of calf, hamstrings and rectus femoris muscle where the muscle was stretched and held in that position for 30 seconds with 3 repetitions which were given by the therapist. 3. Balance training where the participant stood on ground with both feet closed to each other first with eyes open for 30 seconds duration, each participant performed 5 repetitions and then with eyes closed for the duration 30 seconds with 5 repetitions. Group receiving Rhythmic Stabilization technique were instructed to pay attention to the commands of therapist. Participants were taken into standing position on one lower limb while another limb was rested on stool with knee flexed to 90 degrees.

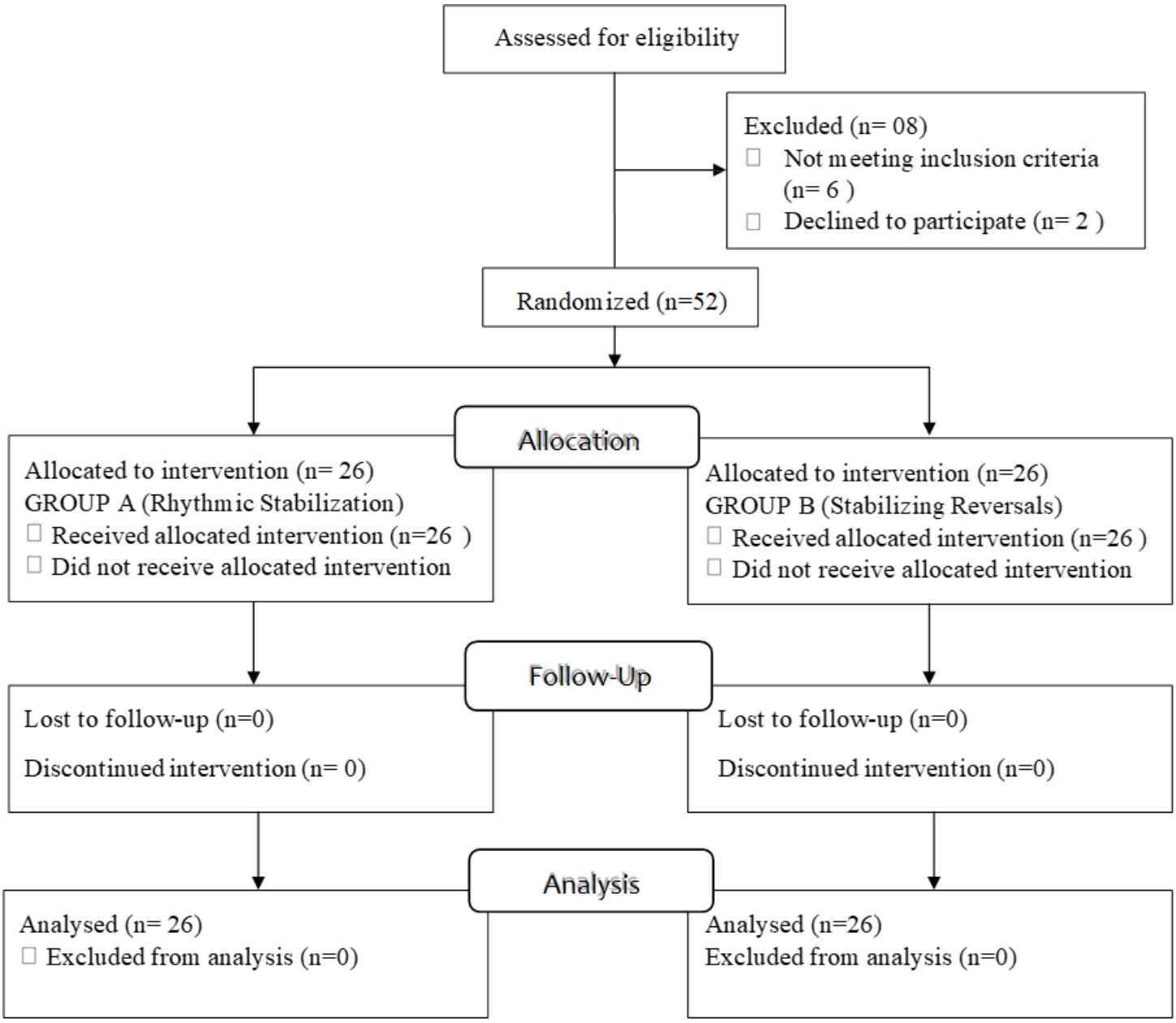
Therapist began by resisting an isometric contraction of the Flexors (agonistic) muscle group and the

Volume 9, Issue 2; March-April 2026; Page No 163-178

participant maintained that position of knee without moving it. Then the therapist increased the resistance slowly, as the participant built a matching force. When the participant responded fully, the therapist moved one hand and began resisting the Extensors (antagonistic) muscle group. Neither the therapist, nor the participant relaxed as the resistance was changed. Then new resistance was built up slowly over the Extensors (antagonistic) muscle group. The Abductors (agonistic) muscle group and Adductors (antagonistic) muscle group of the subjects was resisted by therapist in the similar manner as mentioned above. This treatment was followed on both Right and left knees of the participants. Static commands were given to the subject like, 'no movement at all, don't try to move or stay there'. Whereas group receiving Stabilizing Reversals were instructed to pay attention to the commands of therapist. Participants were taken into standing position on one lower limb while another limb was rested on stool with knee flexed to 90 degrees. The therapist began by giving approximation and then started in strong direction of knee flexors muscle group with resistance and asked the subject to oppose the resistance. As the participant fully resisted the force, the therapist began resisting in another direction and as the subject responded to the new resistance, the therapist moved to resist the new direction. All the extensors, abductors and adductors muscle groups of the subjects were resisted in a similar manner by the therapist. This treatment was followed on both right as well as left knee of the participants. Dynamic commands were given to the subject like, 'stay against me, push against me, don't let me push you'. At the end of session, all the participants from both the group performed SHAVASNA method of relaxation under therapist's guidance for the duration of 5 minutes as cool down technique.

Volume 9, Issue 2; March-April 2026; Page No 163-178

Figure 12: Flow Diagram



Statistical analysis: Data collected from the outcome measures;4-Step Stair Climb Power Test, MiniBESTEST scale and Proprioception, was entered into the MS excel sheet and master chart was created. Quantitative Data was summarized using Mean and Standard Deviation. Statistical analysis of the 4-Step Stair Climb Power Test, MiniBESTEST scale and Proprioception between Group A (Rhythmic Stabilization) and Group B (Stabilizing Reversals) was done using GraphPad Prism Software. Data was initially explored to find out normal distribution by using GraphPad Prism software, where Shapiro-Wilk test was used for analysis. When comparing the data of the Group A and B, differences of their pre and post treatment values were taken, from which Mean and Standard Deviation were calculated and the level of significance was set at 5% ($p < 0.05$).

Results And Tables

Volume 9, Issue 2; March-April 2026; Page No 163-178

TABLE 1: Distribution Of 52 Geriatric Subjects According To Age Group

AGE (YEARS)	60-65	66-70	71-75
NO. OF SAMPLES N=52	15	21	17

GRAPH 1: Distribution Of 52 Geriatric Individuals According To The Age Group

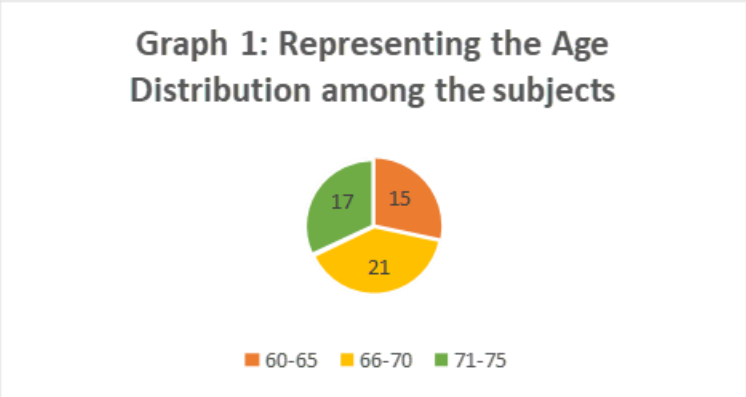
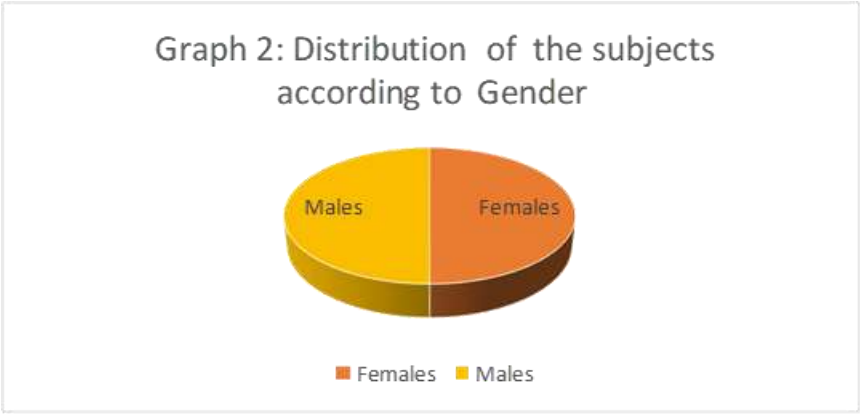


TABLE 2: Distribution Of 52 Geriatric Subjects According To The Groups.

	Group A	Group B
Number of Subjects	26	26
Mean Age	68.5, ± 4.07	67.26, ± 4.19
Number of Female Subjects	13	13
Number of Male Subjects	13	13

GRAPH 2: Distribution of 52 Geriatric individual according to the Gender distribution



Volume 9, Issue 2; March-April 2026; Page No 163-178

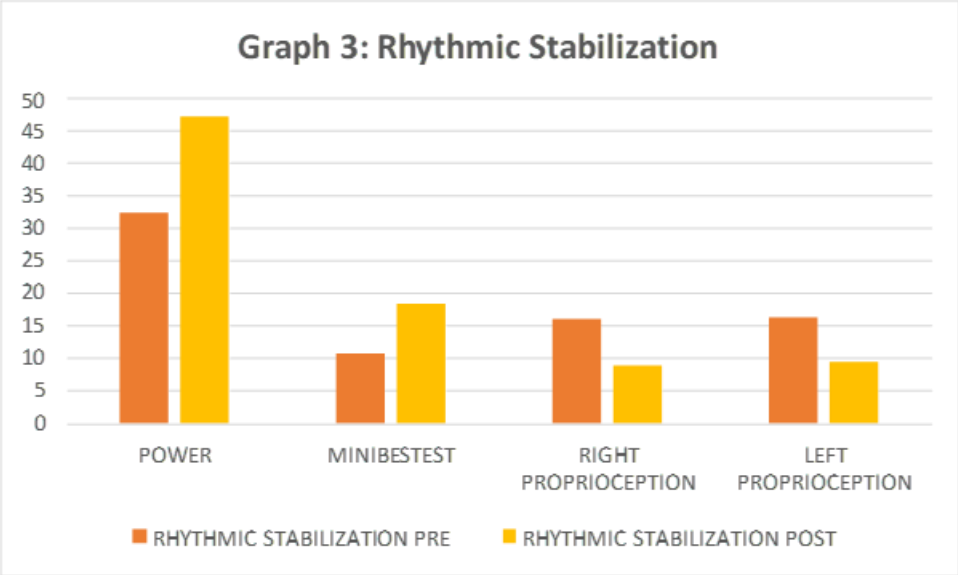
TABLE 3: Representing analysis of Pre and Post treatment data of Power, MiniBESTEST and Proprioception of Right and Left knee in group A (Rhythmic Stabilization) and B (Stabilizing Reversals) after 4 weeks of intervention

OUTCOME MEASURES	GROUP	PRE MEAN SD	POST MEAN SD	NORMALITY	TEST USED	P VALUE P≤0.05
POWER	A	32.50, ±15.70	47.28, ±19.10	NO	Wilcoxon Signed test	0.0001
	B	32.26, ±12.56	60.23, ±21.52	NO	Wilcoxon Signed Test	0.0001
MiniBESTEST	A	10.769, ±2.19	18.38, ±1.32	NO	Wilcoxon Signed test	0.021
	B	10.80, ±0.98	22.80, ±1.78	NO	Wilcoxon Signed Test	0.0001
RIGHT PROPRIOCEPTION	A	16.06, ±2.78	8.95, ±2.50	NO	Wilcoxon Signed test	0.0017
	B	15.87, ±3.03	3.88, ±1.17	NO	Wilcoxon Signed Test	0.0144
LEFT PROPRIOCEPTION	A	16.33, ±2.81	9.48, ±2.26	YES	Paired T test	0.001

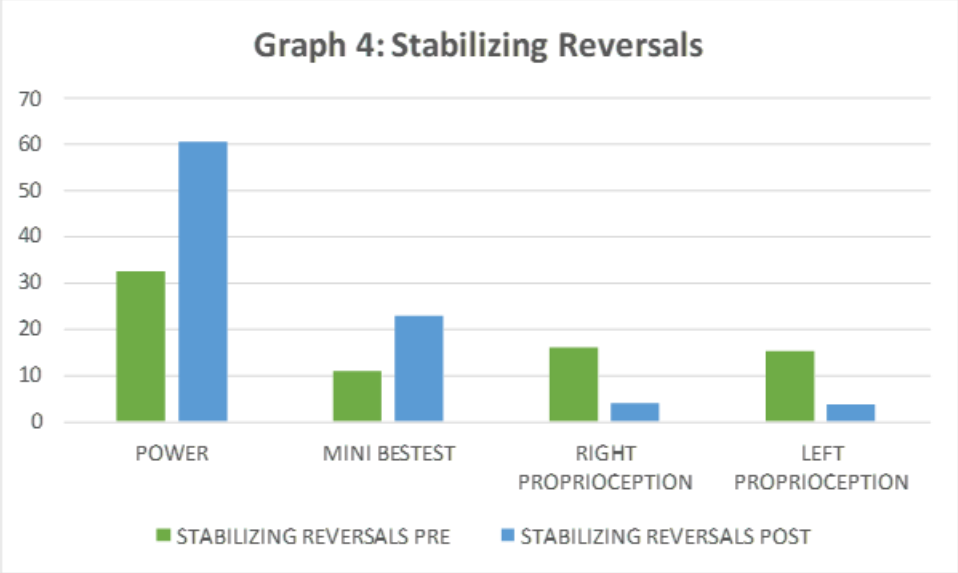
Volume 9, Issue 2; March-April 2026; Page No 163-178

	B	15.13, ±3.30	3.65, ±1.54	YES	Paired T Test	0.001

GRAPH 3: Representing the comparison between Pre and post treatment values of Power, MiniBESTEST along with Proprioception of Right and Left knee of the subjects in the group A (Rhythmic Stabilization).



GRAPH 4: Representing the comparison between Pre and post treatment values of Power, MiniBESTEST along with Proprioception of Right and Left knee of the subjects in the group (Stabilizing Reversals).



Volume 9, Issue 2; March-April 2026; Page No 163-178

Interpretation:

Table 3 and Graph 3 suggest there is significant difference in the Pre-treatment and Post treatment values of Power in the group A receiving Rhythmic Stabilization, with p value

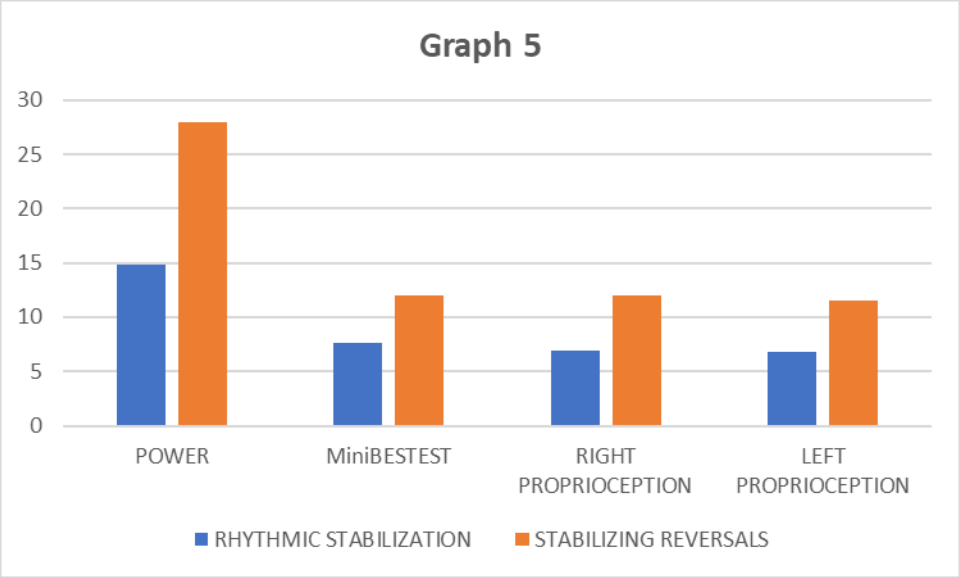
<0.05. Table 3 and Graph 3 suggest there is significant difference in the Pre-treatment and Post treatment values of MiniBESTEST in the group A receiving Rhythmic Stabilization, with p value <0.05. Table 3 and Graph 3 suggest there is significant difference in the Pre- treatment and Post treatment values of Proprioception of the Right and Left knee in the group A receiving Rhythmic Stabilization, with p value <0.05. Table 3 and Graph 4 suggests there is significant difference in the Pre-treatment and Post treatment values of Power in the group B receiving Stabilizing Reversals, with p value <0.05. Table 3 and Graph 4 suggests there is significant difference in the Pre-treatment and Post treatment values of MiniBESTEST in the group B receiving Stabilizing Reversals, with p value <0.05. Table 3 and Graph 4 suggests there is significant difference in the Pre-treatment and Post treatment values of Proprioception of the Right and Left Knee in the group B receiving Stabilizing Reversals, with p value <0.05.

TABLE 4: Represents the analysis and comparison of the post values (difference in the mean of the pre and post values) of the Power, MiniBESTEST and Proprioception of Right and Left knee of the Group A (Rhythmic Stabilization) and B (Stabilizing Reversals).

Outcome Measures	Rhythmic Stabilization Difference of Mean (Post-Pre)	Normality	Stabilizing Reversals Difference of Mean (Post-Pre)	Normality	Test Used	P Value P≤0.05
POWER	14.78, ±6.42	YES	27.96, 11.59	YES	Unpaired T Test	0.0001
MINIBESTEST	7.61, ±2.06	NO	11.96, 1.21	NO	Mann Whitney U Test	0.001
RIGHT PROPRIOCEPTION	6.91, ±2.30	YES	11.97, 2.74	YES	Unpaired T Test	0.0004
LEFT PROPRIOCEPTION	6.83, ±3.17	YES	11.48, 3.21	YES	Unpaired T Test	0.001

Volume 9, Issue 2; March-April 2026; Page No 163-178

GRAPH 5 : Representing the comparison of the post values of Power, MiniBESTEST and Proprioception of the Right and Left knee of the group A (Rhythmic Stabilization) and B (Stabilizing Reversals).



Interpretation: Table 4 and Graph 5, suggests that on comparison Group B (Stabilizing Reversals) has better performance on Power when compared to Group A (Rhythmic Stabilization) with p value <0.01. Table 4 and Graph 5, suggests that on comparison Group B (Stabilizing Reversals) has better performance on MiniBESTEST when compared to Group A (Rhythmic Stabilization) with p value <0.01. Table 4 and Graph 5, suggests that on comparison Group B (Stabilizing Reversals) has better performance on Proprioception of Right and Left knee when compared to Group A (Rhythmic Stabilization) with p value < 0.01.

Discussion: There are few studies conducted on the effectiveness of PNF exercise on geriatric population. The purpose of our study was to examine the effect of Rhythmic Stabilization and Stabilizing Reversal techniques of PNF on knee muscle power, proprioception and balance in geriatric population. Our study included 52 subjects ranging from 60 to 75 years of age who were randomly allocated in two groups, where one group received Rhythmic Stabilization while the other received Stabilizing Reversals technique of PNF. According to table 2 and graph 2 our study had equal distribution of 26 males and 26 females per group. Along with conventional exercises both the groups received Proprioceptive Neuromuscular Facilitation based training for 4 weeks. Assessment of knee muscle power using 4-step stair climb power test, right and left knee proprioception using Goniometer Pro Application and balance using MiniBESTEST scale was taken pre-treatment and on completion of 4 weeks post treatment. Both the interventions mentioned above were given for longer duration.

The results obtained from this study revealed post intervention significant improvement in knee muscle power, right and left knee proprioception and balance. In the study done by ND Reeves, where they examined the torque production and power in geriatric population and found out that there was lower torque as well as lesser power production in the elderly population especially around knee which could be due to increased co-activation of the agonist and antagonist. (28) Therapist's placement of hand while giving Rhythmic

Stabilization is for providing resistance to subject's knee muscles, while performing isometric contraction, this resistance can lead to increase in muscular strength (Gabriel D, 2006). Also previously, the effect of resistance causes neural adaptation at multiple level of neuroaxis but according to the study done by Michael F, Erik J where they observed that effect of resistance training not only elicits significant improvement in strength but it is also accompanied by neural adaptations at the level of cortex as observed by analysing the Movement related Cortical potentials on electroencephalographic activity.(29) In the study

Volume 9, Issue 2; March-April 2026; Page No 163-178

done by Marcelo Pinto, Mauro G et al where they examined the effect of PNF exercises on strength and balance of older population, which included total 16 elderly, where the subjects were given 3 sessions of PNF technique for total ten weeks, in which on the ninth and tenth week the subjects were given Rhythmic Stabilization technique of PNF, they found out that the group receiving PNF showed improvement in production of knee extensor torque with improvement in balance. (30) In our study similar results are observed where according to table 3 and graph 3 our study result shows that there is significant improvement in the values of pre-treatment and post treatment muscle power of the group receiving Rhythmic Stabilization technique. In certain conditions improvement in strength is attributed to supraspinal neural adaptations and not only due to peripheral paths as normally seen, as PNF exercises enhance the proprioceptive response(31) and also promotes higher neural excitement levels on the cortex, due to its characteristics of techniques which was noted in the study by Marcelo Pinto et al, and similar characteristics were followed in our study and that could be the reasons, responsible for the improvement in strength and eventually power production found in our study.

According table 3 and graph 3 our study results show that there was significant improvement in right as well as left knee proprioception after 4 weeks of Rhythmic Stabilization in geriatric population. While giving Rhythmic Stabilization, the therapist places one hand to resist the agonist action and other for antagonist, this placement of hand provides manual contact to the subject. Manual contact used here is not only for applying resistance but also for directing the movement pattern. It also provides a tactile input to the subject. Since there are touch or somatic sensory receptors located in the dermis, which is the bottom layer of the skin. Of total 20 different types of nerve endings which are located in the dermis, few can be easily activated by movement and pressure through mechanoreceptors. (32) Merkel's disc which is located in dermis have a small receptive field.

These receptors are slowly adapting receptors who respond to steady touch and pressure stimulus given over the skin along with Ruffini's corpuscles which are also located in the dermis and have a much larger receptive field, who too are slowly adapting. These receptors get involved in both touch-pressure sensation along with proprioceptive sensation by detecting the push or pull of the skin from one segment of the body on another (33). PNF based training not only involves different patterns but also provides a proper neuromuscular function via stimulation of the proprioceptive system.(34) Similarly, the following may have occurred while giving rhythmic stabilization technique for knee as these PNF exercises were performed with manual resistance provided by a therapist, eliciting maximum motor recruitment through the stretch reflex, manual contact, verbal stimulation, force irradiation, and visual-auditory biofeedback, all of which improve sensory compensation in the elderly as suggested by previous clinical studies. Similar results are obtained in our study where there is significant improvement in right and left knee proprioception in the group receiving rhythmic stabilization.

Rhythmic stabilization caused improvement in knee proprioception by activating the mechanoreceptors and improved the knee muscle power, these factors directly contribute to improvement in balance. Due to the increase in strength and power of the knee muscle, the subjects could have performed well post treatment on sit to stand test of anticipatory component of MiniBESTEST scale, as strength of quadriceps is equally important to perform sit to stand, with minimal loss of balance. (35) Position of subjects leg while giving Rhythmic Stabilization could have lead to improvement in one leg standing test of Anticipatory component of the test. Similarly, improvements were seen on fall risks in elderly receiving proprioceptive neuromuscular facilitation technique program where rhythmic stabilization was assigned to the subjects in a study done Marcelo P, Mauro G, et al, where the subjects performed better on berg balance scale, improvement was also noticed in knee extensors strength level post training. These results were obtained as result of proprioceptive integration and other central modulation processes and not any peripheral adaptations which was recorded on surface electromyography, similar observations were recorded according to table 3 and graph 3, were the data signifies significant improvement in pre and post training values on MiniBESTest scale in the group receiving rhythmic stabilization technique.

Muscular adaptations which contribute to the strength improvement include the hypertrophy, changes in descending neural drive, increases in motor unit firing

Volume 9, Issue 2; March-April 2026; Page No 163-178

rate, motor unit synchronization and alteration in agonist-antagonist co-activation. According to the study done by Kofotolis, Vrabas, Vamvakoudis, Papanikolaou and Mandroukas (2005) their results demonstrated alterations in the cross-sectional area of the muscle vastus lateralis ($p < 0.05$) after a PNF training regimen and therefore PNF resisted exercises lead to hypertrophy of the muscles. In a study done by Pamela R, Alison S, and Tisha S, et al on muscle activation and strength produced by manual resistance technique of PNF when compared to resistance applied by TheraBand they found out that the manually resisted PNF produced greater muscle activation than that produced by elastic TheraBand on surface electromyography of the stimulated muscles. (36) As the traditional resistance applied via manual contact is tailor made according to the response of the subject, similar pattern of resistance application was followed in our study. Stabilizing reversals technique of PNF causes increases in strength and stability by enhancing cross resistance between agonist and antagonist muscles using very minimal motion especially when joint stability and balance between agonist and antagonist is compromised. Kim and Jung were able to achieve activation in the transversus abdominis and internal oblique abdominal muscles along with the activation of deeper muscles of lumbar spine using stabilizing reversal technique of PNF, this study also proved that there was reduction in pain, improvement in functional movements of the subjects receiving this technique which was due to increased stability of the deep muscles in subjects with chronic low back pain. Similar results are found in our study as according to the data in the table 3 and graph 4 there is significant improvement in the muscle power of the knee joint in subjects receiving stabilizing reversals technique of PNF on comparing their pre-treatment to post treatment values.

There are various receptors namely mechanoreceptors located in the dermis which are stimulated through manual contact. These mechanoreceptors play an essential role in knee proprioception and they are found to be reduced in the elderly population. Stimulation of this mechanoreceptors takes place while giving stabilizing reversals technique of PNF which could be the reason behind increase in the right and left knee proprioception post treatment. Initially approximation is given to the knee joint of subject receiving stabilizing reversal technique where it causes facilitation of the weight-bearing and contraction of the antigravity muscles, also promotes stabilization and helps in resisting various components of motion. This quick type of approximation is nothing but a force applied quickly to elicit a reflex-type response. The muscle contraction following the approximation are thought to occur as a result of stimulation of joint receptors. (37) This stimulation of joint receptors could also lead to increase in proprioception of knee joint post treatment of stabilizing reversals technique of PNF. Similar results are found in our study, according to table 3 and graph 4 our study results proved that there was significant improvement in right and left knee proprioception after 4 weeks of Stabilizing Reversals in geriatric population. According to the previous studies it has been reported that PNF training aids in improvement of muscle endurance (Kofotolis, et al 2005), muscle power (Klein, et al 2002), and also selected functional tasks (Klein, et al 2002) or activities like sit to stand, balance and mobility for those elderly who underwent PNF based training. These improvements could probably be related to the increase in cross sectional areas of the muscles (Kofotolis, et al.,2005). This could have also led to improvement in the anticipatory component of balance where due to increase in power of knee extensors have caused reduction in sway while performing sit to stand test and standing on one leg. Therefore, stabilizing reversals technique of PNF, works on both sensory as well as motor system of balance thus improving the balance of the subjects receiving this technique. Similar findings have been noted in our study, according to the data in Table 3 and Graph 4, there is significant difference in the pre training and post training values of the group receiving stabilizing reversal technique of PNF with significant improvement in balance as based on scores of MiniBESTEST scale.

According to foldvari et al 2000, the ability to perform various task in activities of daily living, independence in doing these activities as well the functional capacity depends not only on absolute muscle strength but on the velocity of movement and eventually power generation of those muscles. Studies done on human also show that there is increase in time required to produce absolute and relative forces during voluntary muscle contractions in elderly, therefore they have reduced ability to generate power and accelerate the limb. These alterations have negative effect on

Volume 9, Issue 2; March-April 2026; Page No 163-178

protective reactions which are used before or during a fall. Several studies also report that the differences in elderly population's skeletal muscle power could explain the diverse variability in their function and disability. Another prominent feature of this population include decrease in both muscle mass and muscle strength and also changes in muscle composition. Reduction in muscle mass along with reduction in number of both type I and type II muscle fiber with decline in cross sectional area of muscle are few of the contributing factors to poor physical function in this population. Due to reduction in cross sectional area of muscle mass and muscle fiber type there is certainly reduction in generation of muscle power in geriatric population.

N.Kofotolis did a study to see the effect of PNF training on muscle fiber type and cross sectional area after 8 weeks of PNF lower extremity training, they did muscle biopsy on vastus lateralis muscle and found that the mean percentage of IIA type muscle fiber was significantly increased. PNF training involves patterns that have spiral, diagonal direction which are in line with the topographical arrangement of muscles of the human body and they are also similar to various actions and movements performed in sports which facilitate the biarticular muscles. These movements recruited various synergistic muscles and also imposed a load on quadriceps and hamstrings muscle varying responding to the resistance applied by the therapist in the given direction. While applying Stabilizing reversals the direction of resistance applied was in spiral direction like noted in the previous studies, also here the subjects had to concentrate on the direction of the force of resistance applied without having visual feedback, heavily relying on tactile feedback through manual contact and less likely on the verbal command. Subjects who received rhythmic stabilization were asked to resist the isometric contraction of knee agonistic muscle group without the intention to move and as the resistance was built slowly, the therapist moves the hand to the antagonistic muscle group of the knee which is why the subject can understand as well as predict the change in direction of resistance. As age advances the maximum isometric force decreases, the muscles fatigue rapidly and the rate of tension development is slower. It also appears that with aging the concentric contractions are more affected than eccentric contraction due to changes in neuromuscular system. (38) In rhythmic stabilization technique there occurs isometric co-contraction of the muscles around the joint which leads to improvement of muscle strength which has been observed in our study but according to Marcelo P, Mauro G, et al (2011) when there occurs muscular coactivation around the knee joint it leads to reduction in power production in elderly population and this co-activation influences the capacity to produce force in shorter period of time in the elderly population. The technique of Stabilizing reversals works on isotonic contraction of the muscle with the intent to move and resist against external force and the technique of rhythmic stabilization works on isometric co-contraction of the muscles, with the intention to remain quiescent. (Adler et al 2014, Jim K, Hye W, et al 2018). Therefore, the subjects receiving stabilizing reversals could have performed better on 4 step stair climb test denoting improvement in their power values as observed in the data according to the table 4 and graph 5 where there is significant difference in the values of power of the group receiving stabilizing reversals technique of PNF compared to the group receiving rhythmic stabilization technique of PNF.

PNF technique theorizes that the motor function should be corrected via neuromuscular system through the stimulation of proprioceptors located in the joints, tendons and muscles, making use of voluntary muscle contraction; because the longer the sensory stimulation from the periphery, the larger the number of stimuli that arrive to the CNS, causing the response, accordingly, will also be larger (39) The subjects in stabilizing reversal technique group initially received approximation at the knee joint, this approximation which was quick in nature elicited a reflex type response which stimulates the receptors present in the joint. Located in the deepest layers of the skin are encapsulated endings called Ruffini endings which are involved with the perception of touch and pressure. They are slowly adapting and are particularly important in signaling any continuous skin deformations such as tension, stretch as they are found in joint capsule and assists in the function of joint position sense/proprioception. (40) Stabilizing reversal technique of PNF involves application of resistance where resistance is tailor made according to the subject's reaction to the resistance applied by the therapist and this resistance is built up gradually. Once the subject starts fully resisting, the therapist shifts the direction and now the subject has to detect the new

Volume 9, Issue 2; March-April 2026; Page No 163-178

direction and resist accordingly. This procedure demands sound concentration of the subject in detection of the direction with minimal verbal and visual feedback, due to which the subject has to heavily rely on the sensory stimuli given through the manual contact.

Golgi tendon organs are the receptors located in the proximal and distal tendinous insertion of the muscle whose function is to monitor the tension within the muscle. This may have led to stimulation of the golgi tendon organ receptors located in the knee who sense the tension in the muscle while giving Stabilizing Reversals technique who send Ia afferent fibers on the spinal level which gives off collaterals branches, interact with the interneurons in the spine and then sends signals to the alpha motor neurons in the golgi tendon organ of the targeted muscles where the effect of this connection is inhibitory causing relaxation of the targeted muscle hence working on the principle of reciprocal inhibition. Hence, the above must have occurred while giving Stabilizing Reversal technique of PNF in which the agonist and antagonist muscle work together where one contracts and the other muscle relaxes and is further inhibited to prevent the muscle from working against one-another. (41) Muscle spindle are the receptors who lie parallel to the arrangement of muscle fiber and monitor the change in muscle length via the Ia and II spindle afferent endings as well as the velocity changes via Ia endings. Since Stabilizing reversals technique aids in the stimulation of the above-mentioned receptors, it may have reflected in the improvement of proprioception, which is also observed from the results in the table 4 and graph 5 where there is significant difference in the proprioception of the right and the left knee of the group receiving stabilizing reversals technique of PNF when compared to data of group receiving rhythmic stabilization technique of PNF. The limitation of this study was that dominance of the leg was not assessed along with level of individual physical activity/ lifestyle of the subjects were not considered. Hence, the present study concludes that, Stabilizing Reversals Technique is effective in improving knee muscle power, knee proprioception and balance in geriatric population in comparison to Rhythmic Stabilization.

References:

1. Suzan B O'Sullivan, Schmitz T.J, Fulk G.D ; Physical rehabilitation: examination of coordination and balance, ed6.Phy.Reha.2014 P.226.
2. Cesari M., Vellas B., Gambassi G. (2013). The stress of aging. Exp. Gerontol.48, 451– 456.
3. Sieber C. C. (2017). Frailty-from concept to clinical practice. Exp. Gerontol. 87, 160– 167.
4. Waqar M. Naqvi: physiotherapy in community health and rehabilitation ed.2:ch.5,principle in geriatric rehabilitation.P-129
5. Daubney ME, Culhan EG, Lower-extremity muscle force and balance performance in adult aged 65 years and older PhyTher.1992;79:1177-1185.
6. Berg K. Balance and its measure in the elderly a review physio can 1989;41:240-240.
7. Bacsi AM, Colebatch JG. Evidence for reflex and perceptual vestibular contributions to postural control. Exp Brain Res. 2005;160(1):22–8.
8. Kristinsdottir EK, Fransson PA, Magnusson M. Changes in postural control in healthy elderly subjects are related to vibration sensation, vision and vestibular asymmetry. Acta Otolaryngol. 2001;121(6):700–6.
9. Brocklehurst, J. C., Robertson, D. & JamesGroom,P. (1982) Clinical correlates of sway of old age - sensory modalities. Age Aging 11, 1-10.
10. Dornan, J., Fernie, G. R. & Holliday, P. J. (1979)Visual input in the control of postural sway. Arch.Phys. Med. Rehabil. 59, 586.
11. Horch, K. W., Clark, F. J. & Burgess, P. R. (1975) Awareness of knee joint angle under static conditions. J. Neuroph.ysio1. 38, 1436-1447.
12. Carpenter JE, Blasier RB, Pellizzon GG (1998) The facts of muscle fatigue on shoulder joint position sense. Am J Sports Med 26(2): 262-265.
13. Proske U (2005) what is the role of muscle receptor in proprioception? Muscle nerve 31(6):780-787.
14. Verrillo RT (1979) change in vibrotactile threshold as function of age. Sens Process 3(1):49-59.
15. Behse F. Buchthal (1971) normal sensory conduction in the nerves of the legs in man . J neurol neurosurg PSY 34(4):404-414.
16. Fall in older adults: A barrier to active ageing, CH.2, p 3- 24.

Volume 9, Issue 2; March-April 2026; Page No 163-178

17. Troy Blackburn, Kevin M, et al Balance and Joint Stability: The Relative Contributions of Proprioception and Muscular Strength, , Journal of sports rehabilitation Volume 9 issue4, pg 315-328,
18. Frederick S. Kaplan, James E. Nixon, Mark Reitz, Lynne Rindfleish & Judy Tucker (1985) Age-related changes in proprioception and sensation of joint position, Acta Orthopaedica Scandinavica, 56:1, 72-74.17.
19. Jonathan F, comparison of leg power and leg strength with INchanti stud: which influence mobility more? The journals of gerontology series: a biological sciences and medical sciences 58 (8), Pg 728-733, 2003.
20. Pereira MPP, Gonçalves M. Proprioceptive neuromuscular facilitation improves balance and knee extensors strength of older fallers. ISRN Rehabil. 2012;402612:7.,
21. Youdas JW, Arend DB, Exstrom JM, Helmus TJ, Rozeboom JD, Hollman JH J, Comparison of muscle activation levels during arm abduction in the plane of the scapula vs. proprioceptive neuromuscular facilitation upper extremity patterns. Strength Cond Res. 2012 Apr; 26(4):1058-65.
22. Sharma V, Kaur JJ et al, Effect of core strengthening with pelvic proprioceptive neuromuscular facilitation on trunk, balance, gait, and function in chronic stroke. Exerc Rehabil. 2017 Apr; 13(2):200-205.
23. Kofotolis N, Vrabas IS, Vamvakoudis E, Papanikolaou A,Mandroukas K. Proprioceptive neuromuscular facilitation training induced alterations in muscle fibre type and cross sectional area. Br J Sports Med.2005;39(3):e11.
24. Adler SS, Beckers D, Buck M. Proprioceptive Neuromuscular Facilitation: an Illustrated. DB Publishing. Warszawa 2009:19-44.
25. Basmajian and Nyber, Rational Manual Therapies, Chapter 11 "Proprioceptive Neuromuscular Facilitation" by Vicky L. Saliba, Gregory S. Johnson and Cheryl Wardlaw, page no 259.
26. Cho, Hyuk-Shin, Hyo-Seob et al, The Effects of Upper and Lower Limb Coordinated Exercise of PNF for Balance in Elderly Woman, Journal of Korea Proprioceptive Neuromuscular Facilitation Association, 2015; 13(4): 189-196.
27. Jae-Wook Shin,Seung-Min Lee, Jwa-Jun Kim, et al, The Effects of Stabilizing Reversal and Rhythmic Stabilization in Proprioceptive Neuromuscular Facilitation Techniques on the Static Balance in Normal Female Adult. Journal of Korea Proprioceptive Neuromuscular Facilitation Association, 2015; 13(3): 119-125.
28. N. D. Reeves, C. N. Maganaris, and M. V. Narici, "Plasticity of dynamic muscle performance with strength training in elderly humans," Muscle and Nerve, vol. 31, no. 3, pp. 355–364, 2005.
29. Michael F, Erik S, Gammon E, et al, Resistance training induces supraspinal adaptations; evidence from movement related cortical potentials, Euro Journal of applied Physiology, 2010 July, 109(5): 923-933.
30. Marcelo Pinto Pereira1 and Mauro G, et al, Proprioceptive Neuromuscular Facilitation Improves Balance and Knee Extensors Strength of Older Fallers, International Scholarly Research Network ISRN Rehabilitation Volume 2012, Article ID 402612, 7 page doi:10.5402/2012/402612.
31. N. Kofotolis and E. Kellis, "Effects of two 4-week proprioceptive neuromuscular facilitation programs on muscle endurance, flexibility, and functional performance in women with chronic low back pain," Physical Therapy, vol. 86, no. 7, pg 1001–1012, 2006.
32. Kathleen A, Lamkin K, Marko B, sensors: natural and synthetic sensors, Biomechatronics, 2019.
33. Joseph F, quantitative human physiology second edition, 2012.
34. Sajjadi E, Olyaei G, Talebian S, Hadian M, Jalaei S, Mahmoudi R, et al. The effect of muscular fatigue on cervical joint position sense in young and healthy men and women: A preliminary study. Modern Rehabilitation. 2014;8(1):43-51.
35. Kei Miyoshi, Teiji Kimura, Yoshiharu Y, et al, Effect of ageing on quadricep muscle strength and on forward shift of center of pressure during sit to stand movement from a chair, July 2005, Journal of physical therapy sciences 17(1) : 23-28.
36. Pamela R, Alison S, and Tisha S, et al Differences in Shoulder Muscle Activation

Volume 9, Issue 2; March-April 2026; Page No 163-178

Patterns During Proprioceptive Neuromuscular Facilitation Using Manual and Elastic Band Resistance, athletic training & sports health care vol 3, no.2.

37. Adler SS, Beckers D, Buck M. PNF in practice: an illustrated guide.
38. Anne Shumway Cook, Motor control Theory and practical applications, 2nd edition section 2, chapter 9 Aging and Postural Control, Page no 288.
39. Cruz-Machado SS, Cardoso AP, Silva SB. Et al, the use of Irradiation principle of Proprioceptive neuromuscular facilitation in rehabilitation program, 2007 Latin American Scientific Initiation Meeting and 7. Latin American Graduate Meeting; 18- 19.
40. Hall JE: Guyon and hall textbook of medical physiology ed 13, Saunders Philadephia, 2016) & Siegel A & Sapni N, essential neuroscience ed3, Walters, luwers , Philadephia 2016.
41. Kayla H, Tyler W, Wyatt et al, PNF: its mechanism and effect on range of motion and muscular function, J Hum Kinet. 2012 Mar; 31: 105–113

Volume 9, Issue 2; March-April 2026; Page No 163-178