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# Effectiveness of Ankle Proprioceptive Neuromuscular Facilitation in Improvement of Balance and Gaitin Spastic Diplegic Cerebral Palsy: A Randomized Control Trial

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## 1. Introduction

As a neuromotor condition, cerebral palsy(CP) predominantly affects posture, muscle tone, and movement development. Damage to thegrowing brain during the prenataltoneonatal eraistheunderlyingpathogenesis.ChildrenwithCPmayovertimedevelopavarietyofsecondary disordersthatwillhaveavarietyofeffectsontheirfunctionalabilities,eventhoughtheunderlying neuropathologic damage is non-progressive. (1) According to nonprogressive problems that

happened in the growing fetal or immature brain, CP refers to a spectrum of chronic disorders of mobility and posture that limit activities. In addition tomusculoskeletal issues, the motor impairments of CP frequently come with difficulties of sensation, perception, cognition, communication and behavior. (2)

The worldwide incidence of CP in developedcountryis approximately1.6 cases per 1000livebirths. (3)Since India is a developingnation, it isbelieved that thereal incidencemaybe substantially greater than the estimated 3/1000 live births. As per latest statistical information, there are about 25 lakh CP children. In India, patients with CP may have a variety of problems, such as motor impairmentswhichmayaffectbalanceandgait.(4) Common factors responsiblefor CP include neonatal asphyxia ischemia, maternal infections, metabolic problems, toxicant consumption by the mother,andunusualgenetic illnesses,variablessuchas cordprolapse, and labor obstruction that can impact delivery. Othercausesinclude encephalopathy, neonatal stroke, untreated jaundice, severe infections, premature babies with low birth weight. (2)

CP iswidelydivided into numerous forms,with spasticCPaccountingforroughly70–80% of cases and being the most prevalent. The subtypes of spastic CP include hemiplegia, diplegia, and quadriplegia. Athetoid CP, which accounts for 10–20% of cases. Approximately 5–10% of instances with CP are ataxic, 10% of instances are mixed CP, which mixes elements of the other categories. These percentages are approximations, because the severity of each type's CP varies greatly, depending on location and extent of brain damage. (5)

Cerebral palsy (CP) is a non-progressive upper motor neuron injury that results in common motor disabilities. Other CP characteristics, such as loss of postural control and lack of movement, can lead to the development of musculoskeletal problems. These issues originate as a result of spasticity in the hip, knee, and ankle joints. Spasticity is a type of velocity-dependent resistance, or a motor disease. Children with spastic diplegic CP showed motor impairmentsin the ankles (the distal region) than in the knees. Ankle spasticity is associated with restricted ankle joint movement. The reduced ankle joint movement in children with cerebral palsy is intimately related to gait and balance performance.

Spasticity is one of the symptoms ofupper motor neuron lesion that affects a child's functionality, restrict daily activities, and reduce their quality of life (6). The most common form
ofCP,spasticdiplegia,primarilyaffectsthelowerlimbsmorethanupperlimbandhasasignificant impactonfunctionalperformance(7). Dueto increased musclestiffnessparticularlyintheleg muscles, spastic diplegic cerebral palsy adversely affects balance and walking.

When thespastic muscles are stretched at a particularspeed they respond in an exaggerated fashion.They contract, blocking the movement. This hyperactive stretch reflex may occur at thebeginning, middle or near the end of the rangeof movement. There are increased tendon jerks,occasional clonus and other signs of upper.
motor neuron lesions. The abnormal postures are held by tightshorter spastic muscle groups whose antagonists are weak, or apparently weak in that theycannot overcome the tight pull of the spasticmuscles and so correct the abnormal postures. Changes in spasticity and postures may occurwith excitement, fear or anxiety and painwhich increase muscle tension.

Commonlyused treatments for spastic diplegia include pharmacological (botulinum toxin, intrathecalpumps),andsurgicalmanagement(orthopedicsurgery),occupationaltherapy,physical therapeutic intervention such as Neuro-Developmental Therapy, constraint-induced movement therapy, Sensorimotor training programs, balance training, and Proprioceptive Neuromuscular Facilitation to improve balance, gait, coordination and lower limb function.

(9),(10)

Proprioceptive Neuromuscular Facilitation (PNF) is a special technique of stretching that are frequently used in clinical settings to increase both active and passive range of motion in an efforttoenhancemotorfunctionandsupportrehabilitation.Whenattemptingtoenhancerangeof motion, PNF is regarded as the best stretching technique, particularly with relation to rapid alterations [(11)]PNFtechniqueswereusedtofacilitatemuscleelongationorfacilitation,supposedly through enhanced inhibitory mechanism affecting the target muscle and/or improving muscle strength through excitatory mechanism affecting the target muscle, to aid in the rehabilitation of clients with spasticity and paresis. Herman Kabat demonstrated that the PNF approach is useful
andeffectiveforincreasingmuscleflexibility.Thepatient'svoluntaryeffortisverballystimulated by dynamic directives while resistance and stretching are manually provided to the muscles engagedinmassmovementpatterns.Thestrategiesinvolvedwithapplyingmaximalresistanceto the patterns of mass motions are fundamental. Maximal resistance is thought to be the most significant method of stimulating the proprioceptors. [(12)]
PNFfocusesondiagonalmassmovementpatternsthatimitatefunctionalmovement.PNF employsamulti-sensorystrategythatincludestheauditory,visual, andtactilesystemsinorderto support thesemass movement patterns.Through theuseofseveral senses and manual contacts, it encourages movement, PNF enables the patient to comprehend what typical movement feels like. PNF functions on basic principles such as patterns, manual pressure, verbal stimulation, visual cues, timing, resistance, quick stretch.[(11)]
Most of the studies done in stroke patients where PNF is considered very effective for improvement of gait and balance. While there is less literature available in CP. Hence this study will focus on the effect of ankle PNF on balance and gait in spastic diplegic CP.

## 2. Material and Method:

Acomparativeexperimentalstudy Randomized controlledtrial in Aurangabad, Maharashtra, India. The study was commenced after taking ethical committee.

**Inclusion Criteria**: Childwithspasticdiplegic cerebralpalsy,bothgenders, Age– Above3years, independentstandingfor3minutes, Subjectwhois ableto followtheinstruction, ModifiedAshworth scale– 2in lowerlimb muscles, GMFC LEVEL–level1–level2, MMSE score morethan 24.

**Exclusion Criteria**: Any fixed deformity, contracture,fractures,3months post-surgeryandBotulinum toxin, anygenderandchromosomalabnormalities /syndrome, anyvision,hearingimpairment, Patientswithmentalretardation, Patients with medical co-morbidity(CHD), Anyinvoluntarymovement, unwilling to give consent.

**Sample Size**: Forty-two participants were taken, and they were divided into two groups one which is experimental group in that we have given ankle PNF and conventional treatment and second group which is control group in that only conventional treatment was given.

**Data Collection:**Informed consent was taken from parents prior to study. Before starting the intervention, the pretest scores were recorded as outcome measures.

**Procedure**
All the participants will be selected according to exclusion and inclusion criteria after proper screening. All the information regarding the purpose and objectives of the study will be explained to the parents/guardians in their preferred language. Written informed consent will

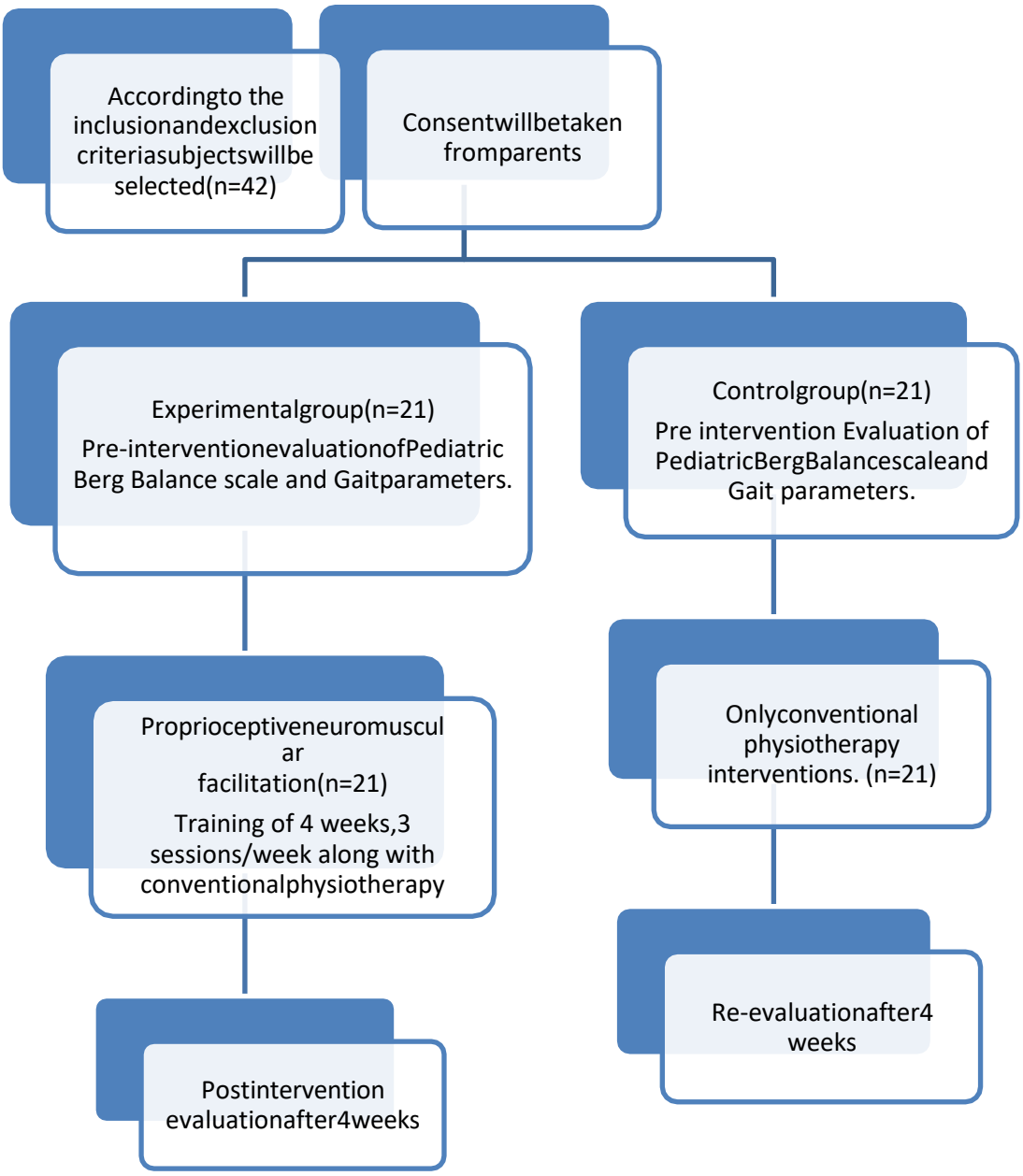
be taken.
Participants will have to give a short interview to gather demographic data.
Data will be recorded and kept ready for further statistical analysis. Results will be recorded after analyzing the scores.
After receiving the ethical clearance from ethical committee of MGM University of Health Sciences the process of gathering the data will be commenced.

The participants will be randomized into two groups, A and B. Group A will be the experimental group and group B will be the controlling group.
Group A will receive conventional physiotherapy.
Group B will receive Ankle PNF techniques like rhythmic initiation, rhythmic stabilization and slow Reversals along with conventional physiotherapy.

Measurements will be taken at pre and post interventions with help of pediatric berg balance scale, and gait parameters. At the end of the study an inter group comparison will be made on the basis of which the results of study will drawn.
Experimental group and group B will be control group.

Group A will receive Ankle PNF techniques like rhythmic initiation, rhythmic stabilization and slow Reversals along with conventional physiotherapy.
Group B will receive conventional physiotherapy which will include patient education, myofascial release, stretching of tight structures, neuromuscular electrical stimulation, strengthening exercises, wobble board, Swiss ball, Bosu ball, throwing and catching ball, orthosis, splinting and bracing, parallel bar walking, treadmill walking.

Measurements will be taken at pre and post interventions with help of pediatric berg balance scale,and gait parameters. At the end of the study an inter-group comparison will be made on the basis of which the results of study will be drawn.




## 3. Result

This study included 42 subjects. Graph depicts comparison between pre and post outcome parameters like PBS, stride length, step length, cadence of group A and group B respectively. A paired t test was done to compare between pre intervention and post intervention in both groups. There was a significant difference in the pre and post intervention reading for both the group A and group B at outcome measures in spastic diplegic CP.

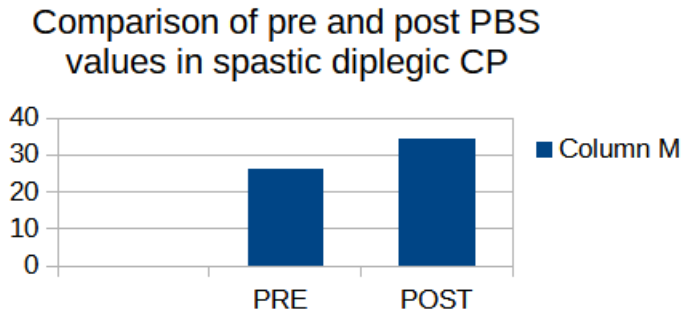
**GROUP A - EXPERIMENTAL GROUP**

Table 1: Comparison of pre and post PBS values in spastic diplegic CP

| Outcome measurements | Pre intervention group A MEAN SD | Post intervention group A MEAN SD | T value | P value |
|---|---|---|---|---|
| PBS | 26.28 ± 2.30 | 34.47 ± 2.35 | 24.96 | <0.0001 |

On comparison of pre and post PBS values in spastic diplegic CP children using Kolmogorov Smirnov test P value obtained was < 0.0001 statistically significant.

GRAPH 1 - Comparison of pre and post gait parameters (stride length, step length, cadence) in spastic diplegic CP children.



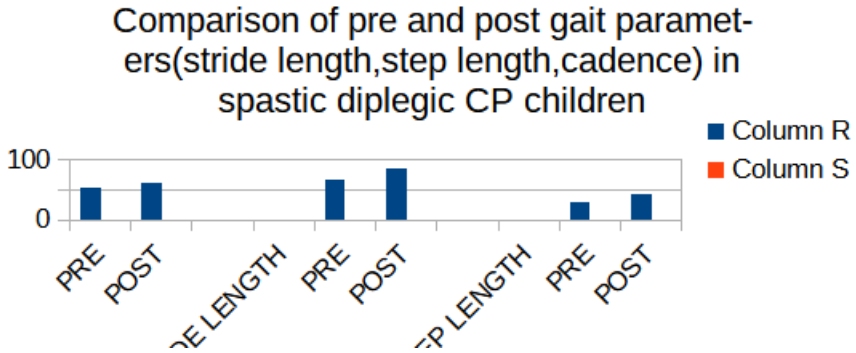

There was a significant difference in the pre intervention and post intervention PBS values in spastic diplegic CP children using ankle PNF along with conventional physiotherapy.

TABLE 2: - Comparison of pre and post gait parameters (stride length, step length, cadence) in spastic diplegic CP children

| Outcome measurements | Pre intervention group A MEAN SD | Post intervention group A MEAN SD | T value | P value |
|---|---|---|---|---|
| cadence | 52.71 ± 3.73 | 58.71 ± 3.66 | 19.94 | <0.0001 |
| Stride length | 67.57 ± 3.85 | 87.04 ± 7.76 | 24.20 | <0.0001 |
| Step length | 30.04 ± 2.37 | 41.71 ± 3.88 | 24.86 | <0.0001 |

On comparison of pre and post gait parameters (stride length, step length, cadence) values in spastic diplegic CP children using Kolmogorov Smirnov test P value obtained was < 0.0001 statistically significant.

GRAPH 2: Comparison of pre and post gait parameters (stride length, step length, cadence) in spastic diplegic CP children




There was a significant difference in the pre intervention and post intervention gait parameters (stride length, step length, cadence) values in spastic diplegic CP children using ankle PNF along with conventional physiotherapy.

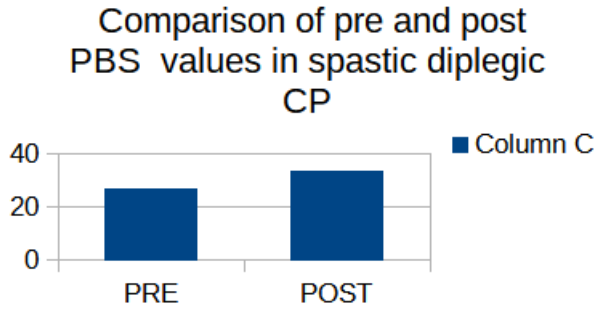
**GROUP B- CONTROL GROUP**

TABLE 3 Comparison of pre and post PBS values in spastic diplegic CP

| Outcome. measurement's | Pre intervention group A MEAN SD | Post intervention group A MEAN SD | T value | P value |
|---|---|---|---|---|
| PBS | 27.19 ± 1.14 | 33.71 ±1.64 | 13.852 | <0.0001 |

On comparison of pre and post PBS values in spastic diplegic CP children using Kolmogorov Smirnov test P value obtained was < 0.0001 statistically significant.

GRAPH 3-Comparison of pre and post PBS values in spastic diplegic CP

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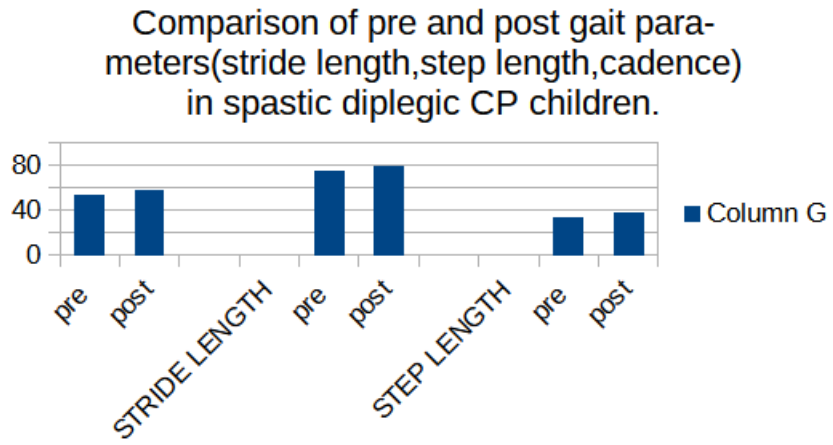
There was a significant difference in the pre intervention and post intervention PBS values in spastic diplegic CP children using ankle PNF along with conventional physiotherapy.

TABLE 4 - comparison of pre and post gait parameters (stride length, step length, cadence) in spastic diplegic CP children

| Outcome measurements | Pre intervention group A MEAN SD | Post intervention group A MEAN SD | T value | P value |
|---|---|---|---|---|
| cadence | 54.09 ± 4.24 | 58.71 ± 3.66 | 15.636 | <0.0001 |
| Stride length | 79.85 ± 7.74 | 74.71 ± 4.03 | 24.824 | <0.0001 |
| Step length | 34.14 ± 4.0 | 38 ± 2.94 | 30.945 | <0.0001 |

On comparison of pre and post gait parameters (stride length, step length, cadence) values in spastic diplegic CP children using Kolmogorov Smirnov test P value obtained was < 0.0001 statistically significant.

GRAPH 4: Comparison of pre and post gait parameters (stride length, step length, cadence) in spastic diplegic CP children.




There was a significant difference in the pre intervention and post intervention gait parameters (stride length, step length, cadence) values in spastic diplegic CP children using ankle PNF along with conventional physiotherapy.

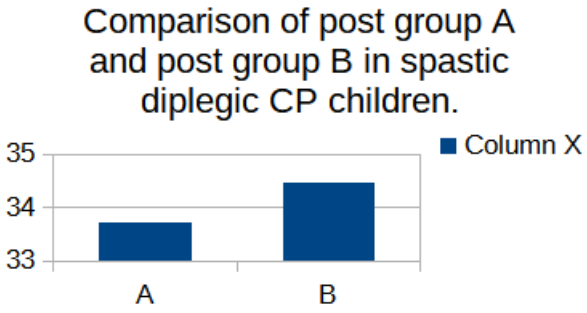
**COMPARISON OF GROUP A AND GROUP B**

TABLE 5: Comparison of post group A and post group B in spastic diplegic CP children

| Outcome measurements | Post intervention group A MEAN SD | Post intervention group B. MEAN SD | T value | P value |
|---|---|---|---|---|
| PBS | 33.71 ± 1.64 | 34.47 ± 2.35 | 1.105 | <0.0001 |

On comparison of post group, A and post group B PBS values in spastic diplegic CP children using Kolmogorov Smirnov test p value obtained was <0.0001 statistically significant.

GRAPH 5: Comparison of post group A and post group B in spastic diplegic CP children.



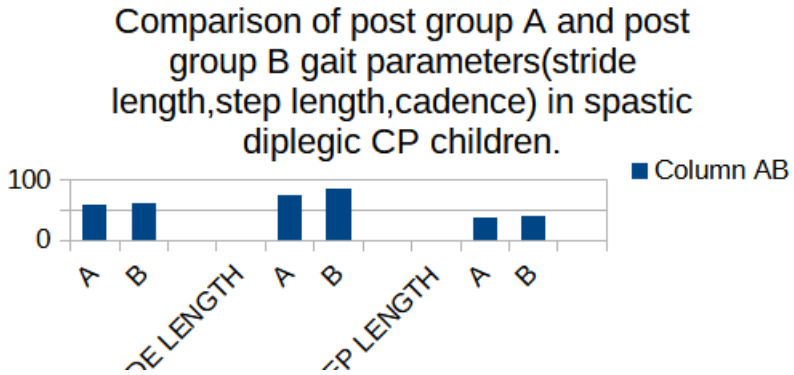

There was a significant difference in the post intervention group A and post intervention group B PBS values in spastic diplegic CP children using ankle PNF along with conventional physiotherapy.

TABLE 6: Comparison of post group A and post group B gait parameters (stride length, step length, cadence) in spastic diplegic CP children

| Outcome measurements | Post intervention group AMEAN SD | Post intervention group B.MEAN SD | T value | P value |
|---|---|---|---|---|
| cadence | 58.09 ± 4.24 | 62.28 ± 4.37 | 2.77 | <0.0001 |
| Stride length | 74.71 ± 4.03 | 87.04 ± 7.76 | 8.34 | <0.0001 |
| Step length | 38 ± 2.94 | 41.71 ± 3.88 | 3.587 | <0.0001 |

On comparison of post group, A and group B gait parameters (stride length, step length, cadence) values in spastic diplegic CP children using Kolmogorov Smirnov test P value obtained was < 0.0001 statistically significant.

GRAPH 6: Comparison of post group A and post group B gait parameters (stride length, step length, cadence) in spastic diplegic CP children.




There was a significant difference in the post group A and post group B gaitparameters (stride length, step length, cadence) values in spastic diplegic CP children using ankle PNF along with conventional physiotherapy.

**Discussion**

Present study aimed to evaluate the effectiveness of PNF training in improvement of balance and gait in spastic diplegic cerebral palsy. Most of the studies were done in stroke patients where PNF is considered effective.

Jung Ho et al conducted a study where they applied PNF on stroke patients and concluded that PNF technique improved the balance and decreased their fear of falling. Diagonal patterns used lead to increased activity of muscles and coordination of muscles. Most characteristic feature of spastic diplegic CP is that it affects the lower limb muscles, which impacts the lower limb function. Ann H Tilton et al reported in their study that spasticity can have a significant functional impact on child with cerebral palsy. Kovela Rakesh krishna et al investigated the effect of PNF in improving lower extremity function in adolescent with spastic diplegic cerebral palsy. He reported that PNF reduced the abnormally increased muscle tone and reduces muscle stiffness. Improvements were seen in berg balance scale and gait parameters.

In the study conducted by Sang Wang et al, reported that PNF reduced muscle stiffness and normalised the abnormally increased tone. Another study conducted by Chandan et al, where PNF was compared with task-oriented therapy on lower extremity function in children with CP where both were proved to be beneficial. Furthermore, another study suggests that diagonal PNF patterns are beneficial in treating abnormally increased muscle activity of rectus

femoris, vastus medialis hamstring and gastrocnemius, tibialis anterior. Another study showed that stroke patients at Brunnstrom stages II or III demonstrated decreased muscle tone on affected side after PNF was implemented. Kumar et al demonstrated the effect of PNF on lower extremity function in children with CP. Apeksha Hemant Shirsath et al conducted a study to evaluate the effect of PNF technique for knee and ankle muscles on lower limb performance in subacute stroke.

Guiu-Tula Fx, et. al investigated the efficacy of PNF approach in stroke to improve basic activities of daily living and quality of life. PNF includes diagonal patterns which improves the coordination and balance. The diagonal patterns require skills which improves the strength and range of activity performed this leads to improvement in the activities of daily living and improves the quality of life. Melanie j shaman et al reported that PNF is most effective means to increase range of motion by the way of stretching, particularly in respect to short term gain in range of motion. Furthermore, another study by Preksha Sharma et al reported that PNF training improved lower limb coordination in cerebral palsy child by the means of improvement in strength and range of motion. Diagonal patterns reduced the increased tone and lead to significant improvement of lower limb coordination.

Current study focuses on PNF technique in improvement of balance and gait parameter. Effectiveness of PNF therapy is based on varies theories and principles. One important concept of PNF is autogenic inhibition, which indicates the reflexive relaxation response that takes place in muscle after implementing sustained contraction on it. Techniques such as contract-relax and hold -relax using this principle enhances muscle flexibility. Additionally, PNF also includes principles like repetition, manual contact, patterns, verbal and visual cues. By integrating these elements, technique facilitates the development of new motor patterns and enhancing existing ones. Research suggests that diagonal patterns in PNF requires more muscle strength and balance compared to sagittal plane movements. Significant improvement is seen in berg balance scores when compared pre and post treatment. Gait parameters also showed improvements, when compared pre and post treatment, Cadence, step length and step width showed marked enhancement post treatment.

**Limitations**

Since this study was conducted on 42 spastic diplegic CP children, there is scope for further research on a larger sample size.

## 4. Conclusion

From the analysed data and results, the study concludes that ankle PNF improves balance and gait in spastic diplegic cerebral palsy. In that we have used certain outcomes measures such as paediatric balance scale, gait parameters which include cadence, step length and stride length. In paediatric balance scale both groups showed significant improvement but the group with ankle PNF showed more improvement. In gait parameters which includes cadence, stride length and step length both groups showed significant improvement but the group with ankle PNF showed more improvement.

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