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EFFECT OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION STRENGTHENING TECHNIQUES IN SWISS BALL ON STRENGTH AND COORDINATION FOR ATHETOID CEREBRAL PALSY: A CASE STUDY CATEGORY: CASE REPORT

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***Abstract*:** Proprioceptive Neuromuscular Facilitation (PNF) is a therapeutic approach rooted in neurophysiological principles, designed to enhance neuromuscular control and functional movement through specific patterns and techniques. This paper explores the foundational concepts of PNF, including its historical development, underlying mechanisms, and clinical applications across rehabilitation settings. Emphasis is placed on the facilitation of motor learning, improvement of muscular strength, flexibility, and coordination through diagonal movement patterns and sensory stimulation. The review also discusses the integration of PNF in treating neurological and musculoskeletal conditions, highlighting its efficacy in promoting functional recovery and optimising patient outcomes.

Keywords: Proprioceptive Neuromuscular Facilitation (PNF), Neuromuscular control, Motor learning, Diagonal movement patterns, Rehabilitation techniques, Sensory stimulation, Flexibility and strength training, Functional recovery, Musculoskeletal therapy, Neurorehabilitation.

I. INTRODUCTION:

Cerebral Palsy (CP) is a disorder of movement and posture that appears during infancy or early childhood, resulting from damage to the brain. The damage to the brain is permanent and cannot be cured, but if we start with intervention, more improvement can be made. It is also known as Little's disease, as the term was first described by William John Little in the year 1843, in which he mentioned that spasticity occurs due to damage to the brain during infancy, preterm birth, or birth asphyxia. This was followed by extensive contributions of Osler, Sach, and Peterson, Sigmund Freud, Mac Keith and Polani, and many others, until 2006, when an expert executive panel defined CP as a group of permanent disorders of the development of movement and posture, causing activity limitation, which is attributed to nonprogressive disturbances occurring in the developing fetal or infant brain [1,2].

Prenatal causes include infections, genetic abnormalities, and maternal health conditions. Perinatal causes involve birth asphyxia, premature birth, and low birth weight [3]. Postnatal causes include traumatic brain injuries, infections such as meningitis, and severe neonatal jaundice [4]. The topographic classification of CP is hemiplegia, diplegia, and quadriplegia. Another classification is based on motor function as pyramidal: spastic and extrapyramidal: non-spastic, including athetoid, ataxic, and dystonic [5]. Common characteristics in all types of Cerebral palsy are motor delay, postural imbalance, defect in infantile reflexes, intellectual impairment, and disturbed sensory perception. It primarily affects motor function due to abnormal brain development [6]. The majority of children with CP have difficulty walking and have poor coordination and balance, which impairs their gait and their ability to reach because stability is essential to all movements [7].

Athetoid cerebral palsy, also known as dyskinetic cerebral palsy, is a subtype of cerebral palsy—a group of non-progressive, permanent disorders that cause activity limitation by affecting the developing motor control circuit. These nonprogressive disturbances result from insults during fetal development or in the infant's brain. Cerebral palsy as a group is the most common cause of childhood disability [8]. Dyskinetic cerebral palsy is the second most common subtype of cerebral palsy, comprising around 12% to 14% of patients who are affected, the most common being the spastic subtype [9]. Abnormal postures and movements define athetoid cerebral palsy; these abnormalities are due to impaired muscle tone, movement control, and

coordination and can be described by detailing the typical movements, such as dystonic, extrapyramidal, choreoathetotic, choreoathetoid, or athetoid cerebral palsy [10].
Proprioceptive neuromuscular facilitation (PNF) is considered a very effective therapeutic exercise for the betterment of gait and dynamic balance [11]. PNF involves dynamic stretching techniques aimed at enhancing muscle flexibility and functional outcomes [12]. It is observed that PNF strengthening exercise is primarily utilised in the lower extremities and considerably improves muscle strength balance [13].
A ball can be used to give functional training in muscles for eccentric and concentric hold simultaneously, along with activation of postural mechanisms, which cannot be achieved efficiently in floor exercises. Lateral control and diagonal patterns can be facilitated [14]. Ball exercises enables the use of techniques of muscle elongation, joint mobility in all these patterns mentioned above for activation and strengthening of abdominals and back extensors that can help the child to achieve co -contraction of agonist antagonist and activate reciprocal inhibition making spinal alignment stable but not rigid there by allowing the child to gain postural control against gravity in standing and walking [14].

1.1 PATIENT INFORMATION:
A 7.5-year-old female reported with Athetoid Cerebral Palsy, who has having difficulty in standing and walking independently. She has been under physiotherapy treatment for the past 3 months, which includes Passive Range of Motion (PROM) of all joints, stretching of the calf muscles, hamstrings, and adductors, sit-to-stand, and gait training. The child has been going to a regular school, but does not have good communication skills and not being able to perform her daily activities. Her primary concern is her difficulty with independent standing, walking and going up and down stairs.
In the antenatal history, the mother had no history of fever, jaundice, illness, or hypertension. She was having regular folic acid and iron supplements.
In the intrapartum history, the mother had a pre-term delivery. She gave birth in 7.5 years with a normal delivery in hospital. During birth, the child's birth cry was absent, and her weight was about 2.5kg.
In the postnatal history, there had been no history of admission in NICU or jaundice or any other illness. The family history revealed that, they had a nuclear family with 4 family members.
During developmental milestones, the child had no neck control. She rolled at the age of 1 year, sat with support at the age of 2 year, and sat without support at the age of 2.5 year. She could stand for a little time and that too with support at the age of 4 years.
On observation, the child was ectomorphic built with a poor lordotic posture and tip-toe, wide gait and scissoring gait. Her attitude of the limbs in the upper limb was normal but the child was having coordination issue; in the lower limb, she had a flexor synergy.
In the sensory examination, her superficial sensations, like pain, temperature, touch, and pressure, were present; her deep sensations, like kinesthesia, proprioception, and vibration, were intact; her cortical sensations, like tactile localisation, 2-point discrimination, stereognosis, barognosis, graphesthesia, texture recognition and double simultaneous stimulation, were impaired.
On examination, the range of motion (ROM) testing revealed restricted movement during passive examination. Limitation was also marked in abduction of both shoulder and abduction of the both hip in active examination. As per Modified Ashworth Scale (MAS), the spasticity level was graded as 3. The child was having muscle power of 3+ for both upper limb and 2 for both lower limb by the Manual Muscle Testing (MMT).
All the reflexes like deep tendon reflex and superficial reflex were exaggerated. Coordination like equilibrium and non – equilibrium coordination was impaired.

II. RESEARCH METHODOLOGY:
The primary goal of rehabilitation in the initial phase was to increase the functional movement, Activities of Daily Living (ADLs), postural control and neck control.
Based on previous study findings, the PNF pattern and Swiss ball was given to improve the trunk control and functional balance.
In the first phase the following conventional exercises were performed:
Passive Range of Movement (PROM) for bilateral upper and lower limbs. (10 reps for each limb)
Pelvic bridging. (10 reps)
Stretching of the calf, adductors and hamstring. (10 reps for each lower limbs)
Tandem walking (5 sets)
Walking with the help of swiss ball (10 times)
Sit to stand. (10 reps)

A rest period of 2 minutes was given in between every exercise set, and the entire therapy session was performed for 5 days/week for consecutive 4 weeks.

Figure 1: Calf stretching

Figure 2: Tandem walking

Figure 3: PNF strengthening D1 extension for lower limb

Figure 4: PNF strengthening D1 extension for upper limb

Prior to initiation of the second phase of intervention, PNF strengthening techniques was added with a swiss ball for 15 repetitions for 5 days/week for 4 weeks.

The second phase included the following exercises—

Passive Range of Movement (PROM) for bilateral upper and lower limbs. (10 reps for each limb)

Pelvic bridging. (10 reps)

Stretching of the calf, adductors and hamstring. (10 reps for each lower limbs)

Tandem walking (5 sets)

Walking with the help of swiss ball (10 times)

Sit to stand. (10 reps)

PNF strengthening techniques i.e., D1 flexion, D1 extension and D2 flexion, D2 extension for both upper and lower limbs performed on a swiss ball

A rest period of 2 minutes was given in between every exercise and the entire therapy session was performed for 5 days/week for consecutive 4 weeks.

2.1 Outcome Measures

The Gross Motor Function Classification System (GMFCS) is a standardised 5-level scale used to describe the gross motor function, mainly sitting, walking, and mobility of children and young people with cerebral palsy. It consists of 5 items. Each item is scored on a 0-3. Likert scale, where 0 means does not initiate, 1 means initiates, 2 means partially completes, and 3 means completes. The overall GMFCS score is obtained by adding the responses, averaging them and then converting the result to a percentage score and then labelling them into GMFSC level. Studies have shown that the GMFCS levels have been proven to be important determinants of functioning in daily activities and social participation in individuals with CP [15]. Therefore, prediction of the GMFCS level can play an important role in predicting future functional changes of the child.

The Barthel Index is an international questionnaire assessing a patient's functional ability. It belongs to the group of tools evaluating ADLs. It consists of 10 items. It allows for measuring the degree of independence and determining which activities the patient can perform independently (10 points), with assistance (5 points) or cannot perform them at all and is dependent on another person (0 points). The following 10 activities are assessed: feeding, bathing, grooming, dressing, bowel control, bladder control, toileting, transfers (bed to chair and back), ambulation, stair climbing. Points are allocated as follows: 0 or 5 points per item for grooming and bathing; 0, 5, 10 points per item for dressing, feeding, bowel and bladder control, toilet use, stair climbing; 0, 5, 10, 15 points per item for transfers and mobility (on level surfaces). The final score is calculated by adding up the points from all items. The higher the score, the greater the degree of functional independence. Studies have shown that the Barthel scale plays a very important role in Poland, i.e. it is a tool qualifying patients for long-term care. It allows you to assess the patient's fitness and ability to self-care. The index was developed according to an international scoring scale, which takes into account activities of daily living that the patient can perform alone or with the help of others or cannot perform them alone. [16]

III. RESULTS AND DISCUSSION:

Following the four-week rehabilitation period, the child's post-intervention assessment showed improvement in both strength and balance. The Gross Motor Function Classification System (GMFCS) score of 0.30% with GMFCS level 2.

Similarly, the Barthel index scale score for assessing activities of daily living (ADLs) is increased from 39 in the Pre-test and 70 in the Post-test following exercise. The intervention protocol was well tolerated, with no adverse effects reported throughout the duration of treatment.

Table 1: Barthel scale graph

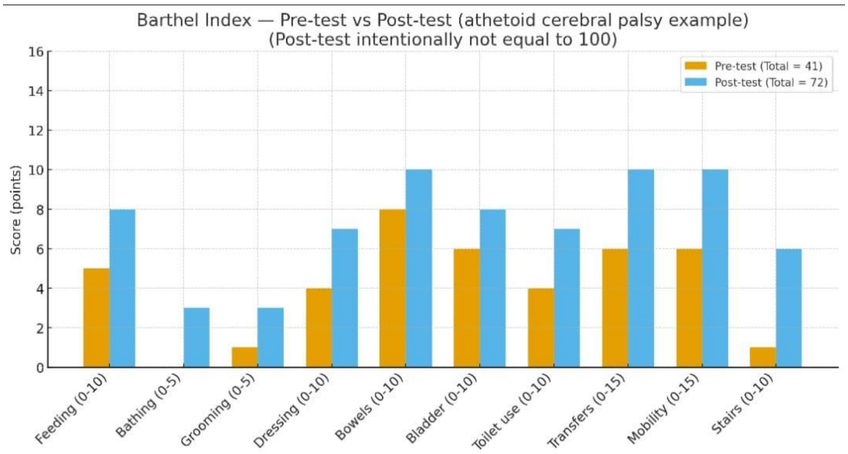
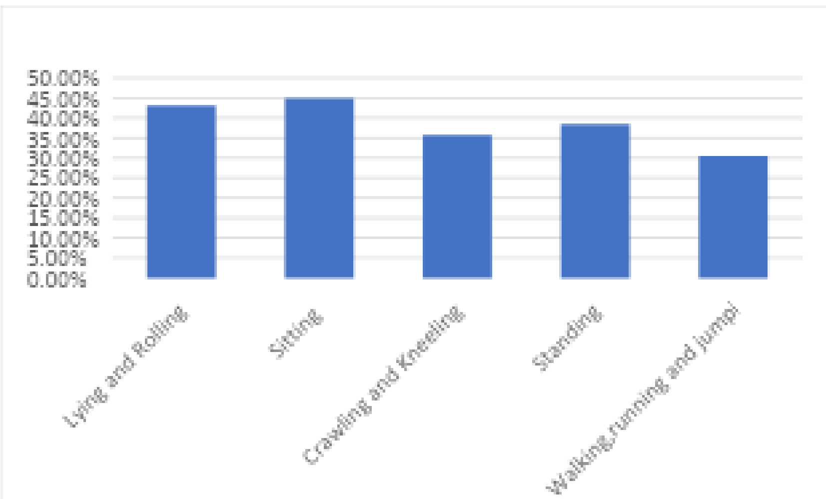


Table 2: GMFCS scale graph



This case study highlights the potential benefits of combining Proprioceptive Neuromuscular Facilitation (PNF) strengthening exercises with Swiss ball training in the rehabilitation of a child with athetoid cerebral palsy. Children with athetoid cerebral palsy often present with fluctuating muscle tone, uncontrolled movements, and limitations in postural stability, all of which restrict their independence[17] (Rosenbaum et al., 2007). Addressing these issues requires interventions that enhance both muscular strength and coordinated balance responses (Damiano & Abel, 1996)[18].

In this program, the child was engaged in stretching, passive mobilization, sit-to-stand practice, tandem walking, and PNF patterned movements performed on a Swiss ball. The inclusion of the ball created a level of instability that promoted continuous activation of core musculature and reinforced trunk control (Behm & Anderson, 2006)[19]. For children with athetoid cerebral palsy, this is especially relevant as poor trunk stability has been identified as one of the main obstacles to efficient mobility and functional task performance (Shumway-Cook & Woollacott, 2012).[20]
The use of PNF techniques alongside the Swiss ball enhanced voluntary motor recruitment and contributed to minimizing unwanted movement patterns. Since PNF methods involve activating multiple muscle groups in coordinated patterns, they are effective in supporting smoother motor transitions and building stability in functional postures . Thus, when paired with the unstable support of the Swiss ball, the intervention promoted a synergistic effect that facilitated both muscular strengthening and improved balance reactions.
A further therapeutic advantage of Swiss ball work is the constant tactile and proprioceptive feedback provided by the surface . This encourages the child to automatically adjust posture and respond to equilibrium demands, gradually improving neuromuscular re-education and trunk alignment .Regular participation in such exercises may also improve muscular endurance and result in better control when maintaining or transitioning between sitting, standing, and walking positions.
Sustainability of outcomes is critical in athetoid cerebral palsy, as joint stiffness and secondary musculoskeletal complications are common with growth and activity limitation (Kerr Graham & Selber, 2003). [21]Findings from this intervention suggest that repeated exposure to Swiss ball and PNF-based exercises may not only reduce functional barriers but also help prevent progressive lower limb stiffness, enabling longer-lasting improvements in motor performance.
Overall, the combination of Swiss ball exercises and PNF strengthening techniques appears to provide a comprehensive and holistic means of therapy, addressing both musculoskeletal strengthening and postural balance training. Such an approach not only reinforces physical capacity but also fosters greater independence in children with athetoid cerebral palsy, supporting its value as an effective rehabilitation strategy (Tsorlakis et al., 2004).[22]

IV. CONCLUSION:

This single case study suggests that Proprioceptive Neuromuscular Facilitation (PNF) strengthening techniques, i.e. D1 flexion, D1 extension and D2 flexion, D2 extension for both upper and lower limbs performed on a Swiss ball, offer a dynamic and effective intervention for children with athetoid cerebral palsy. The inherent instability of the Swiss ball challenges the child's postural control, activating deep core muscles and promoting better trunk alignment. When combined with PNF patterns, these exercises stimulate coordinated muscle contractions, helping to reduce involuntary movements and improve voluntary control.
The Swiss ball encourages active engagement, making therapy both playful and purposeful. PNF techniques such as alternating isometrics and rhythmic stabilisation on the ball enhance joint stability and muscular endurance. These movements not only build strength but also refine balance reactions, which are often compromised in athetoid CP. Over time, children develop improved equilibrium, smoother transitions, and greater control in functional tasks.
In conclusion, integrating PNF strengthening with Swiss ball exercises creates a powerful synergy that fosters both strength and balance. It transforms therapy into a holistic experience—empowering children to move with greater confidence, stability, and independence in their daily lives.

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