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A Comparative Analysis of Neurodevelopment Therapy and Conventional Physiotherapy on Fine Motor Function in Hemiplegic Cerebral Palsy: A Randomized Controlled Trial

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ABSTRACT

Background and Purpose: Cerebral palsy is a neurological disorder affecting motor function, with hemiplegia being a common type. Fine motor function is often impaired, impacting daily activities. Neuro-Developmental Therapy (NDT) and conventional physiotherapy are commonly used interventions. This study aimed to compare the efficacy of NDT and conventional physiotherapy on fine motor function in children with hemiplegic cerebral palsy.

Methodology: This randomized controlled trial included 30 children with hemiplegic cerebral palsy, aged 2-18 years. Participants were randomly assigned to either NDT or conventional physiotherapy groups. Fine motor function was assessed using the Hawaii Early Learning Profile (HELP) at baseline and after six weeks of intervention.

Results: Both groups showed significant improvements in fine motor function. However, the NDT group demonstrated greater improvements compared to the conventional physiotherapy group.

Conclusion: This study suggests that NDT may be more effective than conventional physiotherapy in improving fine motor function in children with hemiplegic cerebral palsy. The findings have implications for clinical practice and highlight the need for further research.

Keywords: Cerebral palsy, hemiplegia, fine motor function, Neuro-Developmental Therapy (NDT), conventional physiotherapy

INTRODUCTION

Cerebral palsy (CP) is a non-progressive neurological disorder resulting from early brain damage, leading to impaired movement and posture, often accompanied by sensory and cognitive deficits. Affecting about 1 in 1,300 live births, CP is the most common cause of neurological disability in children, with approximately 15 million individuals worldwide impacted by this condition (Himmelmann, 2013). Early manifestations of CP frequently include spasticity, particularly affecting the wrist and fingers, resulting in notable hand dysfunctions such as thumb adduction and limited wrist extension (Basu et al., 2014; Arner et al., 2008). Such disabilities significantly compromise daily living activities and functional independence

(Flett, 2003). Spasticity - characterized by increased muscle tone and hyperactive reflexes due to upper motor neuron lesions- exacerbates the challenges faced by children with CP (Mehl-Madrona, 2001). As a result, many children struggle with basic tasks such as grasping objects and executing fine motor skills (Basu et al., 2014). This is particularly problematic in unilateral spastic CP, where the weaker hand is less utilized in daily activities (Fedrizzi et al., 2003).

To understand CP's impact on hand functioning, the International Classification of Functioning, Disability, and Health (ICF) provides a useful framework, outlining the effects on body functions and structures, activities, and social participation (World Health Organization, 2001). CNS integrity is crucial for hand function, and any disruption can limit functional capabilities in essential daily tasks like eating, grooming, or dressing (Ostensjo et al., 2003). Consequently, conventional therapies aim to normalize movement patterns, reduce muscle spasticity, and enhance functional outcomes (Penta et al., 2001). Neuro-developmental treatment (NDT), developed by Bertha Bobath and Karel Bobath, advocates a holistic approach focusing on the quality of movement patterns and overall development rather than merely addressing individual muscle function (Bobath & Bobath, 1984). The NDT philosophy emphasizes the importance of sensory-motor experiences in facilitating development and improving functional capabilities (Kong, 1991). As abnormal movement patterns may lead to further disabilities, interventions must also address associated perceptual and cognitive deficits (Bobath, 1990). Kinesio taping (KT) has emerged as a promising supplementary treatment option for children with CP, primarily in rehabilitation settings (Yasukawa et al., 2006). This technique utilizes an elastic, latex-free cotton tape designed to support weak muscles and enhance motion without restricting soft tissue (Kase, 2001). KT is posited to stimulate peripheral sensorimotor systems, thereby improving proprioception, reducing pain and muscle spasms, and enhancing muscle activation during therapy (McGlone & Reilly, 2010; Shamsoddini et al., 2016). It also appears to promote better handgrip strength by addressing imbalances between spastic wrist flexors and weaker wrist extensors (Kaya et al., 2015). When implemented alongside traditional rehabilitation techniques like stretching and sensory integration therapy, KT can improve voluntary control and coordination of the upper limbs in children with CP (Keklicek et al., 2015). Stretching, in particular, is employed to lengthen muscles, reduce stiffness, and delay contracture development, making it a staple in CP management (Ryan et al., 2008; National Institute for Health and Clinical Excellence, 2012). The efficacy of a combination approach—like integrating KT with traditional therapies—has been supported by evidence showing that it can significantly enhance hand function in children diagnosed with hemiplegic CP (Camerota et al., 2014; Rasti et al., 2017). Studies indicate that properly applied KT can correct abnormal hand postures, enhance range of motion, and inhibit spastic muscle activity, thus facilitating improved functional hand skills (Gönül Acar et al., 2016). However, while many children exhibit immediate benefits from KT, ongoing research is necessary to quantify its long-term effects and better understand the underlying mechanisms of action (Morris et al., 2013). Key considerations for future studies include exploring optimal application techniques, frequency, and duration of taping (Kuo & Huang, 2013; Shamsoddini et al., 2013). The urgency for evidence-based practices in rehabilitative strategies emphasizes the critical role that comprehensive and individualized approaches must play in addressing CP's multifaceted challenges. Ultimately, the overarching goal of therapeutic interventions for children with CP is to promote maximum independence and quality of life as they progress into

adolescence and adulthood, acknowledging the diversity of their needs and potentials (Novak et al., 2013). In conclusion, an integrated rehabilitation plan leveraging NDT, KT, and traditional therapies can potentially yield better outcomes in hand function and overall independence for children living with cerebral palsy.

METHODOLOGY

Population

The population of this study consisted of 250 children diagnosed with Hemiplegic Cerebral Palsy (HCP) attending various rehabilitation centers located in Dehradun. This population encompasses a diverse set of backgrounds and conditions, reflecting the complexity and range of effects associated with hemiplegic cerebral palsy.

Source of Subjects

The source of the subjects for this study was derived from a selection of 30 children identified among those receiving therapy in different rehabilitation centers across Dehradun. These children were specifically chosen based on their diagnosis and the eligibility criteria set for the study.

Sample

The study sample comprised 30 children diagnosed with Hemiplegic Cerebral Palsy, aged between 2 and 18 years. This particular age range was selected to ensure understanding and responsiveness to therapeutic interventions, while also reflecting a significant period for developmental milestones in motor function.

Place

The study was conducted across several rehabilitation centers in Dehradun, ensuring a varied environment representative of the different rehabilitation practices employed within the area.

Study Design

This research utilized a comparative study design, allowing for an assessment of the effectiveness of two distinct treatment approaches: Neuro Developmental Therapy (NDT) and Conventional Physiotherapy. By comparing outcomes between the two groups, the study aimed to elucidate any notable differences in fine motor function as a result of the applied therapies.

Selection Criteria

Inclusion Criteria:

- Children diagnosed with Hemiplegic Cerebral Palsy.
- Accessibility to the parents or primary caregivers for communication regarding the study.
- Age ranged from 2 to 18 years.

Exclusion Criteria:

- Children diagnosed with other developmental disabilities unrelated to hemiplegic cerebral palsy.
- Children younger than 2 years old or older than 18 years old.
- Failure to reach the parent or caregiver responsible for the child's care.
- Any child with a history of trauma or injury within the past month.
- Children who received a Botulinum toxin application to the upper extremity within the past six months.
- Any child who underwent upper extremity surgery (including tendon transfer or tendon lengthening) in the past six months.
- Children displaying altered parameters for any reason.
- Children presenting with fever or showing uncooperative behavior during assessment or treatment.

Variables

The primary variables of interest in this study included:

- Diagnosis of Hemiplegic Cerebral Palsy.
- Measurement of fine motor function.
- The effectiveness of Neuro Developmental Therapy (NDT).
- The effectiveness of Conventional Physiotherapy techniques including stretching and Kinesio Taping.
- Assessment of fine motor skills through the Hawaii Early Learning Profile (HELP), a validated tool for evaluating children with neuromotor dysfunction.

PROCEDURE

Thirty children diagnosed with Hemiplegic Cerebral Palsy, aged between 2 and 18 years, were enrolled in the study after obtaining informed consent from their parents or guardians. Following the enrollment, the subjects were randomly assigned to one of two treatment groups through random sampling methods; one group received NDT, while the other group received Conventional Physiotherapy.

Group Assignments:

- Group 1: Consisted of 15 subjects undergoing Neuro Developmental Therapy.
- Group 2: Consisted of 15 subjects undergoing Conventional Physiotherapy.

Pre-test and post-test evaluations of fine motor function for the upper extremity were conducted using the Hawaii Early Learning Profile (HELP), ensuring both validity and reliability in subjects with neuromotor dysfunction.

The intervention was conducted by a qualified physical therapist who administered 45-minute sessions two days a week for six consecutive weeks.

Intervention Strategies:

- Neuro Developmental Therapy (NDT): The strategies employed for Group 1 were focused on improving fine motor function through techniques promoting postural control and engaging in bilateral functional midline activities, particularly concentrating on the hemiplegic hand. Emphasis was placed on encouraging movement patterns that facilitate proper neural development and motor function.
- Conventional Physiotherapy: For Group 2, conventional physiotherapy techniques were utilized, which included passive stretching and Kinesio Taping (KT) for the hemiplegic hand. Passive stretching aimed to alleviate tightness in the muscles and break down adhesions, which involved gentle and gradual elongation of the muscle lasting 20 seconds, followed by relaxation for an additional 20 seconds, repeated for 3-5 cycles per session.

The Kinesio Taping was applied from the origin of the extensor muscles to the metacarpophalangeal (MCP) joints of the fingers and from the origins of the extensor and abductor pollicis longus to the MCP joint of the thumb. The tape was applied with varying tension (30% tension for muscular zones and 75% for joint areas), targeting the dorsum of the wrist and forearm to facilitate activation of the extensor muscles of the wrist and thumb. The intention of Kinesio Taping in this manner was to improve muscle function and promote joint alignment, addressing common deformities such as wrist flexion and thumb adduction.

RESULT

Subject Information

Table 1- 4 shows the demographic and clinical characteristics of the 20 subjects who participated in the study. There were 10 (50%) male subjects and 10 (50%) female subjects.

Right hand dominance reported in 11 subjects (55%), while 9 subjects (45 %) were left hand dominance. There was no significant difference between both groups in terms of age ($p=0.7059$) mean age of Group A is 9.74 and mean age of Group B is 8.92.

Changes in fine motor function

Mean test scores and standard deviations for both groups are shown in the table 5 and 6 (Paired T test).

The mean and standard deviation values of fine motor function in Group A for baseline assessment is 15.30± 8.769 and final assessment is 23.10± 9.803 with a significant value of ($p<0.001$).

The mean and standard deviation values of fine motor function in Group B for baseline assessment is 12.30± 8.394 and final assessment is 13.80±8.509 with a significant value of ($p<0.001$).

Table 7 shows the mean test scores and standard deviations for both groups for the Unpaired T test. The mean difference for baseline assessment is 3 and for final assessment is 9.30.

The P value for baseline assessment is not significant with a value of ($p>0.4447$) and it is significant in the final assessment with a value of ($p<0.0360$)

Both the groups had improvement in the fine motor function post-treatment. The average improvement fine motor function tended to being higher in Group A (15.30 ± 8.769 versus 23.10 ± 9.803,) than in Group B (12.30 ± 8.394 versus 13.80±8.509).

PROTOCOL

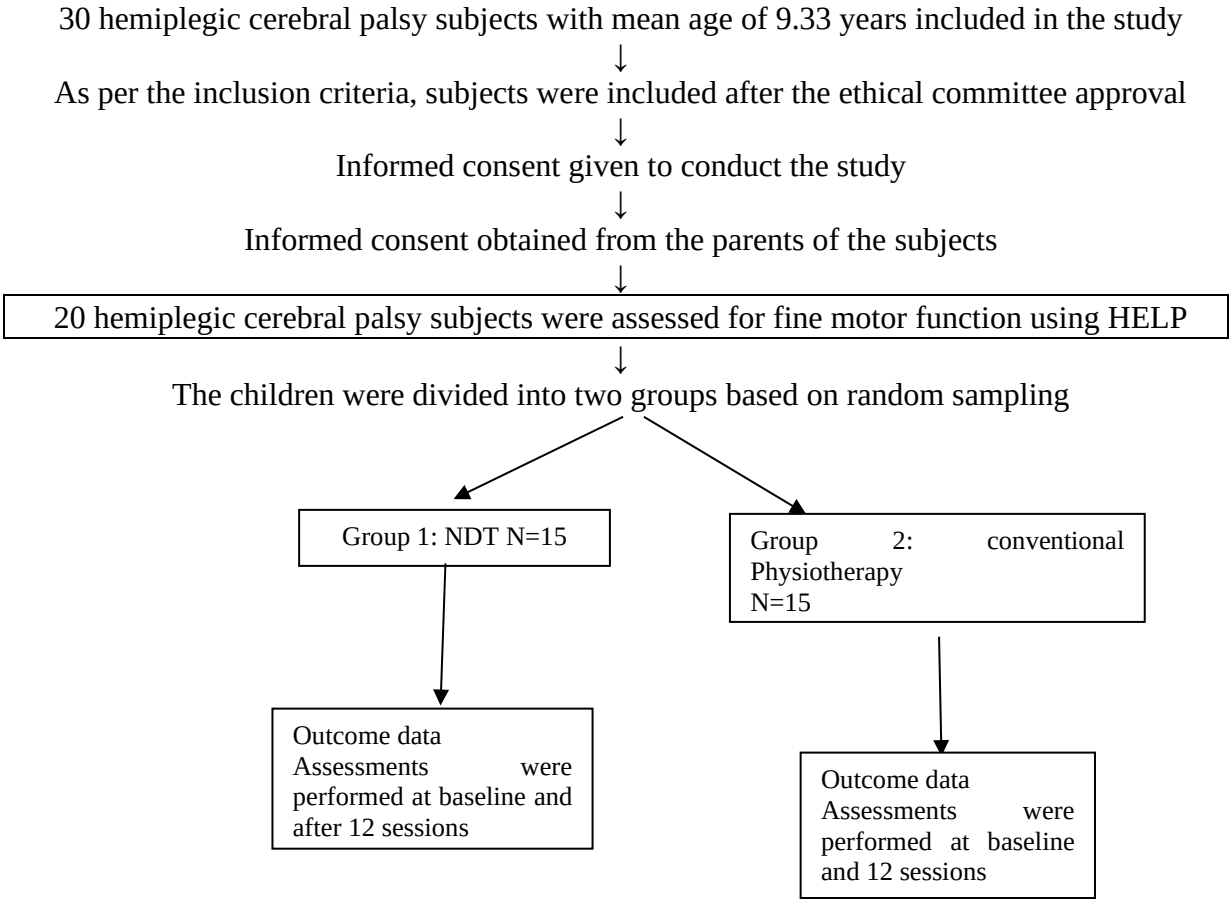


Figure 1: Study flow diagram.

Table No: 1. SUMMARY SHEETS OF GROUP A AND GROUP B

GROUP A						
NDT					**FINE MOTOR FUNCTION**	
Sr. No.	**Name**	**Gender**	**Side**	**Age**	**BASELINE**	**FINAL**
1	A-1	M	Left	12.5	13	19
2	A-2	M	Right	12.1	7	14
3	A-3	M	Right	11.1	14	21
4	A-4	M	Left	9.8	13	18
5	A-5	F	Left	5.1	11	17
6	A-6	M	Left	17.6	32	42
7	A-7	F	Right	2.3	12	23
8	A-8	M	Right	6.9	6	12
9	A-9	F	Left	4.7	30	37
10	A-10	F	Right	15.3	15	28

GROUP B					**.**	
CONVENTIONAL PHYSIOTHERAPY					**FINE MOTOR FUNCTION**	
Sr. No.	**Name**	**Gender**	**Side**	**Age**	**BASELINE**	**FINAL**
1	B-1	M	Left	8.7	19	20
2	B-2	M	Right	5.8	3	5
3	B-3	M	Left	14.4	16	18
4	B-4	M	Left	7.9	8	9
5	B-5	F	Right	3.11	12	13
6	B-6	F	Right	8.2	8	10
7	B-7	F	Left	9.5	5	6
8	B-8	M	Right	2.2	10	11
9	B-9	M	Right	16.3	10	12
10	B-10	M	Right	13.1	32	34

Table No: 2. GENDER DISTRIBUTION

Group	**Group A**	**Group B**
Male (%)	60.0	70.0
Female (%)	40.0	30.0
Male(f)	6	7
Female(f)	4	3

Figure No: 2.

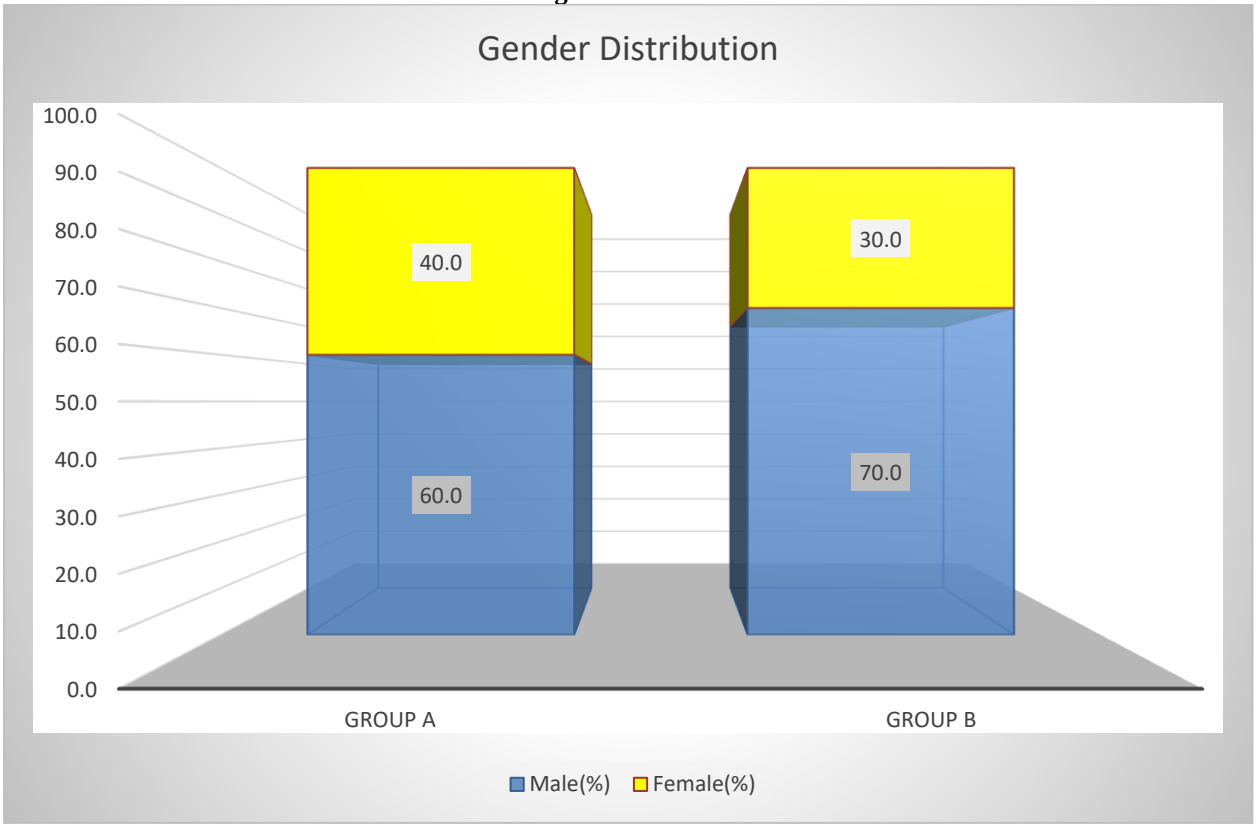


Table No. 3: SIDES INVOLVED

Group	**Group A**	**Group B**
Left (%)	50.0	40.0
Right (%)	50.0	60.0
Left(f)	5	4
Right(f)	5	6

Figure No: 3. SIDES INVOLVED

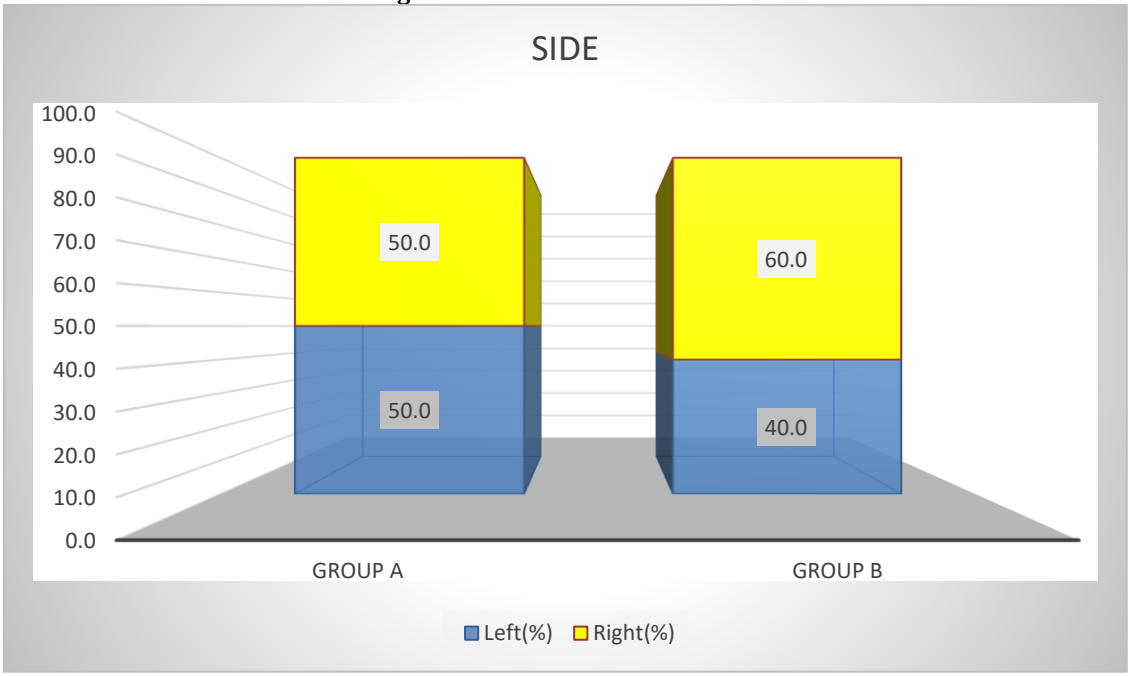


Table No: 4. COMPARISION OF AGE

Unpaired T Test	**Age**	
	Group A	Group B
Mean	9.74	8.92
S.D.	4.923	4.626
Number	10	10
Mean Difference	0.82	
Unpaired T Test	0.383	
P value	0.7059	
Table Value at 0.05 df 28	2.10	
Result	Not-Significant	

Figure No: 4. COMPARISION OF AGE

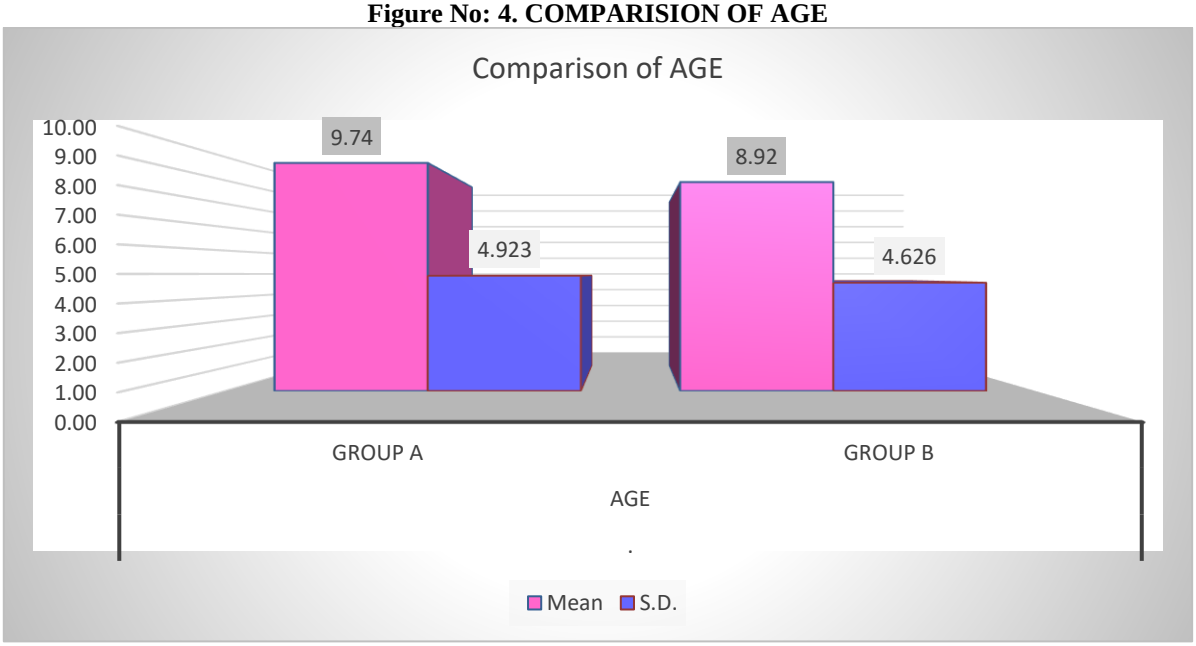


Table No: 5. PAIRED T TEST: GROUP A

Paired T Test	**Group A**	
	FINE MOTOR FUNCTION	
Table No 5	**BASELINE**	**FINAL**
Mean	15.30	23.10
S.D.	8.769	9.803
Number	10	10
Mean Difference	-7.80	
Paired T Test	9.428	
P value	<0.001	
Table Value at 0.05	2.26	
Result	Significant	

Figure No: 5. PAIRED T TEST: GROUP A

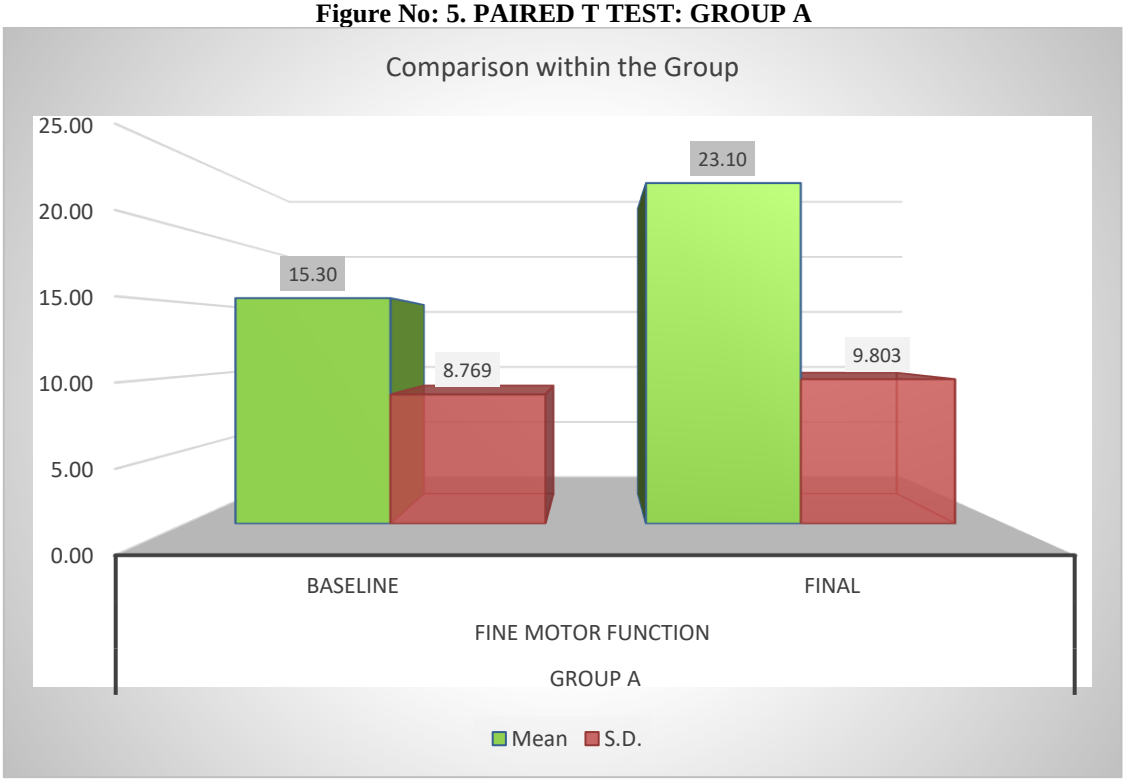


Table No: 6. PAIRED T TEST: GROUP B

Paired T Test	**Group B**	
	FINE MOTOR FUNCTION	
Table No 6	**BASELINE**	**FINAL**
Mean	12.30	13.80
S.D.	8.394	8.509
Number	10	10
Mean Difference	-1.50	
Paired T Test	9.000	
P value	<0.001	
Table Value at 0.05	2.26	
Result	Significant	

Figure No: 6. PAIRED T TEST: GROUP

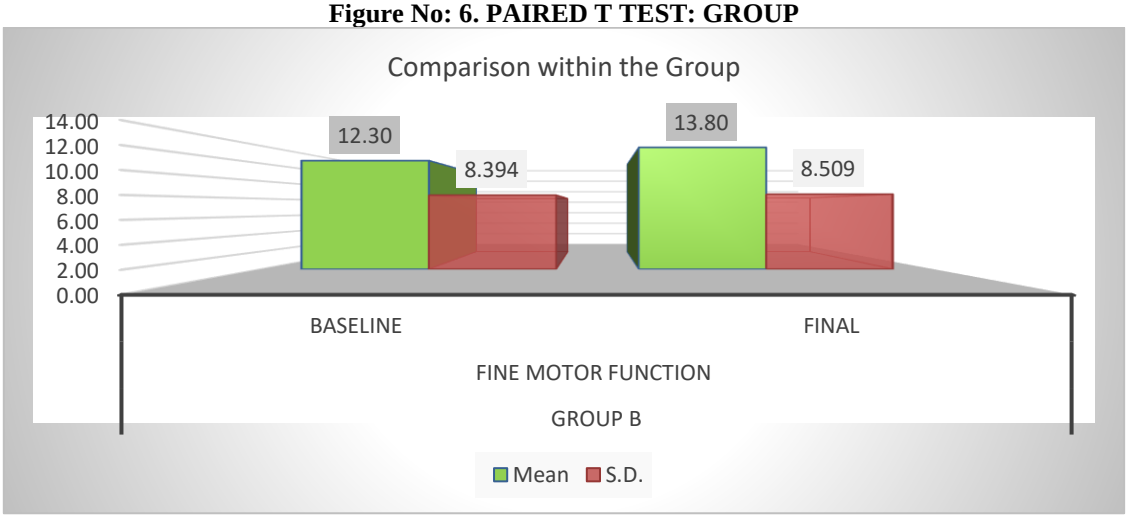
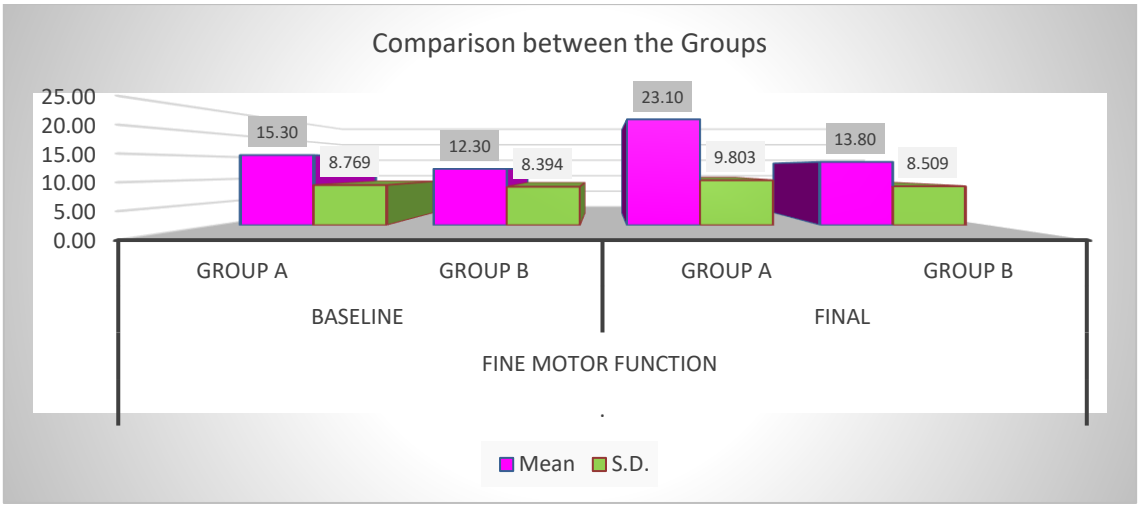


Table No: 7. UNPAIRED T TEST: COMPARISION BETWEEN THE GROUPS

Unpaired T Test	.			
	FINE MOTOR FUNCTION			
	BASELINE		FINAL	
	Group A	Group B	Group A	Group B
Mean	15.30	12.30	23.10	13.80
S.D.	8.769	8.394	9.803	8.509
Number	10	10	10	10
Mean Difference	3.00		9.30	
Unpaired T Test	0.782		2.266	
P value	0.4447		0.0360	
Table Value at 0.05 df	2.10		2.10	
Result	Not-Significant		Significant	

Figure No: 7. UNPAIRED T TEST: COMPARISON BETWEEN THE GROUPS



DISCUSSION

This study was conducted in different rehabilitation centers in Dehradun, involving 20 children with Hemiplegic Cerebral Palsy (HCP) with a mean age of 9.33 years. Subjects were selected based on inclusion criteria following ethical approval. Parents were informed about the study, and written consent was obtained before participation.

Participants were randomly assigned to two groups. Group 1 (n=10) received

Neurodevelopmental Treatment (NDT), while Group 2 (n=10) underwent conventional physiotherapy, including stretching and taping. The fine motor function of the upper extremity was assessed pre- and post-treatment using the Hawaii Early Learning Profile (HELP), a validated and reliable tool for neuromotor dysfunction.

Cerebral Palsy (CP) is a non-progressive brain disorder occurring in early development, often associated with sensory, cognitive, and musculoskeletal impairments. Among upper limb issues, the wrist and hands are most affected, presenting with abnormal postures like thumb adduction and restricted wrist extension. These impairments hinder daily activities due to increased muscle tone and impaired motor control. Both groups showed improvements in fine motor function post-treatment. However, NDT demonstrated a greater improvement (15.30 ± 8.769 to 23.10 ± 9.803) than conventional therapy (12.30 ± 8.394 to 13.80 ± 8.509). This suggests that NDT is more effective in enhancing fine motor function in HCP. NDT focuses on proximal control to enhance distal movement, facilitating fine motor development. Through handling techniques, therapists guide trunk movements to improve extremity function. As proximal control strengthens, distal independence increases, aligning with the proximal-distal principle of motor development. Research suggests that trunk stability is essential for fine motor activities, as motor control progresses from gross to fine movements and from proximal to distal coordination. Observations of typical motor development indicate that children first gain shoulder control before refining movements of the elbow, wrist, and fingers. This principle underlies therapeutic interventions, with occupational and physical therapists emphasizing proximal stability as a foundation for hand function. NDT principles, rooted in neurodevelopmental theories, propose that proximal (axial) stability is essential for fine motor skill acquisition, supporting the use of proximal control strategies in therapy. Postural control and fine motor skills are functionally interconnected. A stable posture is crucial for precise hand movements, such as handwriting. Research indicates that skilled postural control is necessary for efficient reaching and grasping, with postural stability influencing the development of successful grasping in infancy. Studies also show that reaching movements are impaired in infants lacking compensatory trunk control, affecting their ability to stabilize arm movements. Even in adulthood, postural stability impacts manual precision, reinforcing the necessity of trunk stability for optimal hand function.

Future Research

1. The severity of muscle tone in the upper limb, assessed using the Modified Ashworth Scale (MAS), can be considered.
2. Future studies can be conducted with a larger sample size for more robust results.
3. The Manual Ability Classification System (MACS) levels can be included for a more detailed assessment of functional ability.
4. Additional interventions can be compared to determine the most effective method for improving fine motor function in cerebral palsy.
5. Research can be extended to children with spastic quadriplegic and spastic diplegic cerebral palsy.
6. Studies can focus specifically on either right or left hemiplegic cerebral palsy to analyze differences in functional improvement.

Relevance to Clinical Practice

Children with cerebral palsy (CP) frequently undergo physical therapy; however, evidence supporting its effectiveness remains limited. Available studies show conflicting results, with some supporting treatment efficacy while others report minimal impact. This research aimed to

compare the effectiveness of Neurodevelopmental Treatment (NDT) and Conventional Physiotherapy in improving fine motor function in children with Hemiplegic Cerebral Palsy (HCP). Findings suggest that NDT, which emphasizes proximal control to facilitate distal movement, is more effective in enhancing fine motor skills compared to conventional physiotherapy. By improving trunk stability, NDT supports better hand function, aligning with the proximal-distal principle of motor development. Given its effectiveness, NDT can be integrated into rehabilitation programs for children with CP to optimize upper limb function.

This study also contributes to documenting and evaluating the impact of physical therapy programs on fine motor function in HCP. Future research with larger sample sizes and additional classifications (e.g., MAS, MACS) can further validate these findings. Expanding studies to include different types of CP and alternative therapeutic approaches will help refine treatment strategies and improve outcomes for children with CP.

CONCLUSION

The study concludes that Neurodevelopmental Treatment (NDT) is more effective than conventional physiotherapy in improving fine motor function in hemiplegic cerebral palsy by enhancing proximal stability and facilitating better hand function.

Declaration by Authors
Conflict of Interest: None
Source of Funding: None
Ethical Approval: Approved

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