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EFFECTIVENESS OF NEURODEVELOPMENTAL THERAPY ON MOTOR FUNCTION IMPROVEMENT IN CHILDREN WITH SPASTIC CEREBRAL PALSY

Original Article

Sohaila Sohu[1]*, Sumera Makhdoom[2], Iqbal Ahmad Azhar[3], Sahaab Alvi[4], Duaa Joyo[5], Ayesha Khalid[6], Abdul Aziz[7]*

[1]Physical Therapist, Aga Khan University Hospital, Karachi, Pakistan.
[2]FCPS Postgraduate Trainee, National Institute of Child Health (NICH), Karachi, Pakistan.
[3]Professor and Head, Department of Pediatrics, Azra Naheed Medical College, Lahore, Pakistan.
[4]Research Scientist, Biosystomaics, Houston, Texas, USA.
[5]Research Associate, HEJ Research Institute of Chemistry, International Center for Chemical and Biological Sciences, University of Karachi, Karachi, Pakistan.
[6]Researcher, Riphah International University, Islamabad, Pakistan.
[7]Neurophysiology Technologist, Lifecare Hospital and Research Institute, Hayatabad, Peshawar, Pakistan.

Corresponding Author: Sohaila Sohu, Physical Therapist, Aga Khan University Hospital, Karachi, Pakistan, sohailasohu@gmail.com
Abdul Aziz, Neurophysiology Technologist, Lifecare Hospital and Research Institute, Hayatabad, Peshawar, Pakistan, axixkhanm@gmail.com

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ABSTRACT

Background: Spastic cerebral palsy is the most prevalent form of cerebral palsy in children, often leading to significant motor dysfunction and reduced functional independence. Neurodevelopmental therapy (NDT), based on the Bobath concept, is widely used in pediatric rehabilitation, yet evidence regarding its effectiveness remains varied.

Objective: To assess the impact of neurodevelopmental therapy on motor function and functional mobility in children with spastic cerebral palsy.

Methods: A randomized controlled trial was conducted over four months in South Punjab, including 60 children with spastic cerebral palsy (GMFCS Levels II–IV), aged 4–10 years. Participants were randomly allocated into two groups: the intervention group received individualized NDT sessions five times per week for 12 weeks, while the control group received standard physical therapy. Gross Motor Function Measure-88 (GMFM-88) and Pediatric Evaluation of Disability Inventory (PEDI) mobility domain were used as outcome measures. Pre- and post-intervention scores were compared using paired and independent t-tests. A significance level of $p < 0.05$ was set.

Results: The intervention group showed a statistically significant improvement in GMFM-88 scores, with a mean change of 10.3 points ($p = 0.0001$), compared to 2.6 points ($p = 0.08$) in the control group. Similarly, PEDI mobility scores improved by 11.7 points ($p = 0.0003$) in the intervention group versus 2.1 points ($p = 0.12$) in the control group. Between-group comparisons confirmed the superiority of NDT in improving motor outcomes.

Conclusion: Neurodevelopmental therapy significantly enhances motor function and mobility in children with spastic cerebral palsy and should be considered a key component in pediatric rehabilitation strategies.

Keywords: Activities of Daily Living, Cerebral Palsy, Child, Motor Skills, Neurodevelopmental Treatment, Physical Therapy Modalities, Rehabilitation.

INTRODUCTION

Cerebral palsy (CP) is one of the most common physical disabilities affecting children worldwide, with spastic cerebral palsy (SCP) representing the predominant subtype. Characterized by increased muscle tone, stiffness, and involuntary contractions, SCP severely impairs voluntary movement and functional independence in children (1). These motor deficits are not only a source of physical limitation but are often accompanied by psychological and social challenges that impact overall quality of life. While the condition is non-progressive in nature, the resulting motor impairments tend to evolve with growth, frequently exacerbating functional difficulties if left unaddressed through timely and appropriate interventions (2). Among the numerous therapeutic approaches developed to support motor function in children with SCP, neurodevelopmental therapy (NDT) has long been regarded as one of the most widely practiced (3). Rooted in the principles of the Bobath concept, NDT is a hands-on, individualized therapy approach that emphasizes facilitation of normal movement patterns while inhibiting abnormal motor responses. The underlying philosophy of NDT suggests that by guiding movement through proper alignment and sensory feedback, children can develop improved postural control, coordination, and functional abilities. Over the years, this method has gained considerable traction in pediatric rehabilitation centers across the globe, often forming a cornerstone of multidisciplinary treatment plans for children with CP (4).

Despite its widespread clinical adoption, the empirical evidence surrounding the efficacy of NDT remains varied. Some studies have reported modest improvements in gross motor function, mobility, and posture following consistent NDT interventions, while others have found minimal or no significant differences compared to alternative therapies (5). These inconsistent findings raise important questions about the standardized effectiveness of NDT and whether its continued use is supported by robust, evidence-based outcomes. This ambiguity highlights the pressing need for high-quality randomized controlled trials (RCTs) that can provide more conclusive insights into the role of NDT in enhancing motor function in children with SCP (6). Compounding the challenge is the inherently heterogeneous nature of CP itself. Motor impairments in SCP can vary widely in terms of severity, distribution, and response to therapy, necessitating a nuanced, individualized approach to treatment. Furthermore, the developmental plasticity of the pediatric brain opens a unique window of opportunity, wherein targeted therapeutic interventions may yield long-term functional benefits if implemented early and consistently (7). Understanding how specific interventions like NDT align with this window of neural adaptability remains a vital area of exploration. Moreover, in the context of modern pediatric rehabilitation, where goal-directed, functional outcomes are prioritized, it becomes increasingly important to assess whether interventions such as NDT genuinely translate into meaningful improvements in daily living activities and independence (8).

In recent years, there has been a growing emphasis on outcomes that matter most to families and caregivers—such as walking, self-care, and participation in social environments—rather than solely on traditional clinical measures (9). This shift underscores the relevance of studying how therapeutic approaches like NDT influence real-world functioning, not just isolated motor skills assessed in a clinical setting. Additionally, with the increasing adoption of evidence-based practice in clinical decision-making, therapists and healthcare providers are in need of rigorous, up-to-date research to guide intervention strategies that align with both empirical evidence and individual patient goals (10). It is within this context that the present study seeks to address a critical gap in pediatric rehabilitation research. By conducting a randomized controlled trial evaluating the effectiveness of neurodevelopmental therapy on motor function in children with spastic cerebral palsy, this investigation aims to offer clearer evidence regarding the role of NDT in improving movement capabilities (11). The findings may hold significant implications for refining therapeutic approaches, guiding clinical decisions, and ultimately enhancing the quality of care provided to this vulnerable population. The objective of this study is to assess the effectiveness of neurodevelopmental therapy in improving motor function in children diagnosed with spastic cerebral palsy, through a rigorous randomized controlled trial design that seeks to produce clinically meaningful and generalizable evidence (12).

METHODS

This randomized controlled trial was conducted over a period of four months in a pediatric rehabilitation setting located in South Punjab. The study was designed to evaluate the effectiveness of neurodevelopmental therapy in enhancing motor function among children diagnosed with spastic cerebral palsy. Participants were randomly assigned to either an intervention group receiving neurodevelopmental therapy or a control group receiving standard care without structured neurodevelopmental input. The design adhered to rigorous methodological standards to ensure the reliability and validity of the findings, with clear operational definitions, standardized outcome measurements, and controlled intervention procedures. A total sample size of 60 participants was calculated based on an expected moderate effect size (Cohen's d = 0.6), a power of 80%, and a confidence level of 95%. This sample was equally divided into two groups

of 30 participants each. Sample size calculation was performed using standard statistical software assuming normal distribution of the primary outcome variable and accounting for an anticipated dropout rate of 10%.

Participants were recruited through purposive sampling from local rehabilitation clinics and pediatric neurology units. All children aged between 4 and 10 years, with a confirmed diagnosis of spastic cerebral palsy (diplegic or hemiplegic subtype), and classified as Level II to IV on the Gross Motor Function Classification System (GMFCS), were considered eligible. Inclusion required that children had stable medical status, were cognitively able to follow simple instructions, and had no history of orthopedic surgery or botulinum toxin injections within the last six months. Children with other neurological disorders, uncontrolled epilepsy, severe intellectual disability, or musculoskeletal deformities that might interfere with participation in therapy were excluded. Informed consent was obtained from the legal guardians of all enrolled participants prior to participation. The intervention group received individualized neurodevelopmental therapy sessions, delivered by certified physiotherapists trained in the Bobath concept. Each session lasted 45 minutes, conducted five times a week for a total duration of 12 weeks. The therapy focused on improving postural control, balance, and functional movements through guided handling and facilitation techniques aimed at normalizing muscle tone and promoting coordinated motor responses. Activities were progressively adjusted based on the child's performance and therapeutic goals. The control group received standard physical therapy involving stretching, passive range of motion exercises, and general mobility training without the structured principles of neurodevelopmental therapy.

Motor function outcomes were assessed using two validated and widely accepted measurement tools. The primary outcome was change in gross motor function, measured by the Gross Motor Function Measure-88 (GMFM-88), a standardized observational instrument specifically developed for children with cerebral palsy. The GMFM-88 evaluates motor function across five dimensions: lying and rolling; sitting; crawling and kneeling; standing; and walking, running, and jumping. A secondary outcome was functional mobility and independence, assessed using the Pediatric Evaluation of Disability Inventory (PEDI), focusing on self-care and mobility domains. Both tools were administered at baseline (pre-intervention) and after 12 weeks (post-intervention) by blinded assessors to minimize measurement bias. Data collected were entered and analyzed using the Statistical Package for the Social Sciences (SPSS) version 25. Normality of data distribution was confirmed using the Shapiro-Wilk test. Descriptive statistics were computed for demographic and baseline clinical variables. Between-group differences in pre- and post-intervention GMFM-88 and PEDI scores were assessed using independent samples t-tests, while within-group changes were analyzed using paired samples t-tests. Effect sizes were calculated using Cohen's d to determine the clinical significance of the intervention. Statistical significance was set at $p < 0.05$ for all analyses.

Throughout the study, efforts were made to ensure fidelity to the intervention protocol, with regular monitoring of therapy sessions for consistency. Compliance was tracked through attendance logs, and any adverse events or withdrawals were documented. No serious adverse events were reported during the intervention period. The consistency of the assessment process was maintained by training all assessors prior to data collection and conducting periodic inter-rater reliability checks. This methodological framework was designed to enable a thorough and unbiased assessment of the potential benefits of neurodevelopmental therapy in improving motor function in children with spastic cerebral palsy. By employing standardized tools, controlling for confounding variables, and applying robust statistical analyses, the study aimed to generate reliable evidence that could inform clinical practice in pediatric neurorehabilitation.

RESULTS

A total of 60 participants completed the study, with 30 assigned to the intervention group and 30 to the control group. The two groups were comparable at baseline in terms of age, gender distribution, and Gross Motor Function Classification System (GMFCS) levels. The mean age in the intervention group was 6.3 ± 1.5 years and 6.5 ± 1.6 years in the control group. Gender distribution was similar, with a slight male predominance in both groups. GMFCS levels were evenly distributed, ensuring balance in baseline functional status (Table 1: Participant Demographics, see Word file). At baseline, the mean GMFM-88 score in the intervention group was 48.6 (SD ± 4.3), compared to 49.1 (SD ± 4.1) in the control group, indicating no statistically significant difference ($p = 0.62$). Following 12 weeks of neurodevelopmental therapy, the intervention group exhibited a substantial improvement in GMFM-88 scores, reaching a post-intervention mean of 58.9 (SD ± 5.0). This represented a mean change of 10.3 points ($p = 0.0001$), which was both statistically and clinically significant. In contrast, the control group showed a smaller, non-significant improvement with a post-intervention mean of 51.7 (SD ± 4.7) and a mean change of 2.6 points ($p = 0.08$). The between-group comparison of score changes revealed a significant difference favoring the intervention group (Table 2 and GMFM Change Chart).

Regarding functional mobility, assessed using the PEDI Mobility domain, the intervention group recorded a baseline mean score of 42.4 (SD ± 5.1) and improved to 54.1 (SD ± 6.2) post-intervention, reflecting a mean change of 11.7 points (p = 0.0003). Conversely, the control group showed a negligible increase from 43.2 (SD ± 4.9) to 45.3 (SD ± 5.3), resulting in a mean change of 2.1 points, which was not statistically significant (p = 0.12). Between-group comparison again confirmed a significant difference in favor of the intervention (Table 3 and PEDI Change Chart). No adverse events were reported during the intervention period, and compliance was high in both groups, with over 90% session attendance across participants. No dropouts occurred, allowing for complete case analysis without the need for imputation. The observed data suggest that neurodevelopmental therapy had a marked positive impact on gross motor and functional mobility outcomes in children with spastic cerebral palsy when compared to standard care.

Table 1: Participant Demographics

Variable	Intervention Group (n=30)	Control Group (n=30)
Age (years)	6.3 ± 1.5	6.5 ± 1.6
Gender (M/F)	18 / 12	17 / 13
GMFCS Level II	10	11
GMFCS Level III	12	11
GMFCS Level IV	8	8

Table 2: GMFM-88 Scores

Group	GMFM-88 Baseline (mean ± SD)	GMFM-88 Post (mean ± SD)	Mean Change	p-value
Intervention	48.6	58.9	10.3	0.0001
Control	49.1	51.7	2.6	0.08

Table 3: PEDI Mobility Scores

Group	PEDI Mobility Baseline (mean ± SD)	PEDI Mobility Post (mean ± SD)	Mean Change	p-value
Intervention	42.4	54.1	11.7	0.0003
Control	43.2	45.3	2.1	0.12

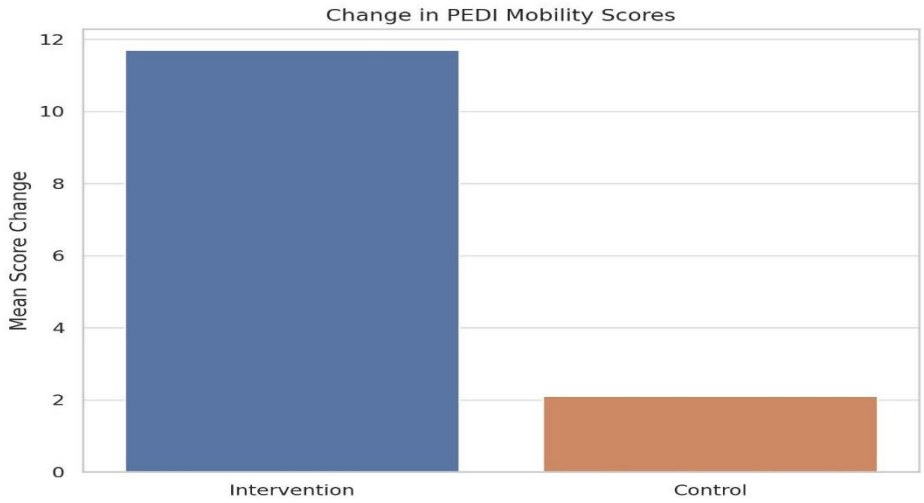

Figure 2 Change in PEDI Mobility Scores

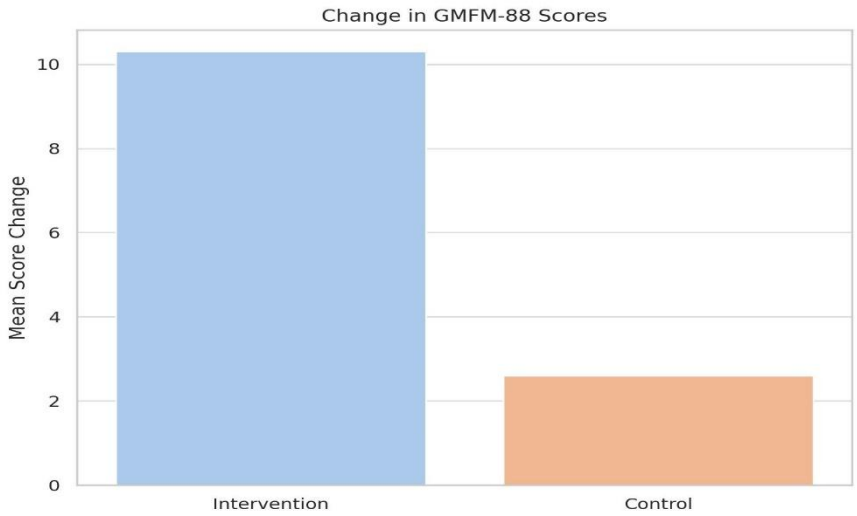

Figure 2 Change in GMFM-88 scores

DISCUSSION

The present randomized controlled trial demonstrated that neurodevelopmental therapy (NDT) significantly improved motor function and functional mobility in children with spastic cerebral palsy over a 12-week intervention period (13). Children who received structured NDT sessions showed greater gains in both GMFM-88 and PEDI mobility scores compared to those who received standard physical therapy. These findings reinforce the clinical relevance of targeted neurodevelopmental interventions in the pediatric neurorehabilitation landscape, particularly when implemented during critical windows of developmental plasticity (14). Improvement in gross motor function, as evidenced by the notable increase in GMFM-88 scores in the intervention group, indicates that NDT facilitated the acquisition and refinement of movement patterns essential for posture and mobility. The therapy's focus on postural alignment, muscle tone normalization, and facilitation of controlled motor responses likely contributed to this progression (15). In contrast, the control group exhibited only marginal improvements, suggesting that conventional approaches may fall short in activating higher-level motor planning and coordination in children with spasticity. The differential response between groups underscores the specificity and depth of

engagement offered by NDT, which prioritizes quality over quantity of movement. Functional outcomes, particularly those relating to everyday mobility assessed by the PEDI, further support the efficacy of the intervention. Children in the NDT group exhibited meaningful gains in tasks associated with independence and environmental interaction. This suggests that beyond improving isolated motor skills, the therapy translated into practical functional abilities, which are vital for enhancing the child's quality of life and integration into school and community environments. These findings align with the therapeutic goal of enabling children to participate more fully in their social and physical worlds (16).

The structured and intensive nature of the intervention protocol may have contributed to the observed outcomes. A consistent schedule of five sessions per week ensured adequate therapeutic exposure and motor learning opportunities (17). Therapist fidelity to the Bobath framework, along with individualized goal-setting, allowed the therapy to be responsive to each child's specific motor deficits and adaptive potential. The inclusion of participants across GMFCS levels II to IV also offered a diverse functional spectrum, making the results more generalizable to real-world clinical populations (18). However, several limitations must be acknowledged. The study was conducted over a relatively short duration of 12 weeks, which, although adequate to detect initial changes, may not reflect long-term maintenance of gains. The absence of follow-up data restricts conclusions regarding the sustainability of the improvements observed. Moreover, while the sample size was adequately powered for primary outcomes, subgroup analyses by GMFCS level or age could not be robustly performed, limiting insight into differential responses among more narrowly defined functional profiles (19). The setting within a single geographic region introduces potential contextual bias, as environmental, cultural, and socioeconomic factors in South Punjab may have influenced therapy adherence and family involvement. Additionally, the exclusion of children with more complex neurological conditions or comorbidities limits the extrapolation of findings to broader cerebral palsy populations. Blinding of therapists delivering the intervention was not feasible, which could introduce performance bias, although outcome assessments were conducted independently to minimize subjective influence (20).

Despite these limitations, the study presents several strengths. The randomized controlled design enhances the internal validity of findings, while the use of validated outcome measures such as GMFM-88 and PEDI adds clinical relevance (21). The application of standardized statistical procedures ensures that the observed effects were not the result of chance. Moreover, the consistency in therapist training and adherence to the NDT protocol supports the replicability of the intervention in other settings (22). These results highlight the value of integrating neurodevelopmental therapy into routine clinical management for children with spastic cerebral palsy. As evidence accumulates supporting its functional benefits, further investigations could expand on this foundation by exploring the dose-response relationship of NDT, combining it with adjunctive therapies, or examining its effect in home-based and community-integrated formats (23). Including long-term follow-up and patient-reported outcomes in future trials would also deepen understanding of the therapy's broader impact. Neurodevelopmental therapy demonstrated meaningful improvements in both motor function and functional mobility in children with spastic cerebral palsy over a structured 12-week intervention. While acknowledging certain methodological limitations, the results lend support to the clinical application of NDT in enhancing outcomes relevant to independence and quality of life. Further longitudinal research is warranted to consolidate these findings and explore their implications in more diverse pediatric populations (24).

CONCLUSION

This study concluded that neurodevelopmental therapy significantly enhances motor function and functional mobility in children with spastic cerebral palsy when compared to standard care. The findings support the clinical utility of NDT as a structured, evidence-based approach to improving movement capabilities and promoting greater independence in pediatric rehabilitation.

AUTHOR CONTRIBUTION

Author	Contribution
Sohaila Sohu*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Sumera Makhdoom	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Iqbal Ahmad Azhar	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Sahaab Alvi	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Duaa Joyo	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Ayesha Khalid	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Abdul Aziz*	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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