

Effectiveness of NDT-Based Early Intervention Programs in Improving Gross Motor Milestones in Children with Global Developmental Delay (GDD)

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ABSTRACT

Background: Global Developmental Delay (GDD) affects 1–3% of children worldwide and manifests as significant delays in motor, cognitive, language, and adaptive domains. Early neurorehabilitation is essential for optimizing developmental trajectories. Neurodevelopmental Treatment (NDT), a hands-on sensorimotor facilitation approach, is widely used in pediatric physiotherapy to enhance postural control and improve functional motor performance. Despite widespread application, the strength of evidence supporting NDT in early intervention for GDD remains limited.

Objective: To evaluate the effectiveness of an NDT-based early intervention program in improving gross motor milestones in children aged 6 months to 36 months diagnosed with GDD.

Methods: A quasi-experimental pre–post intervention study was conducted on 60 children with clinically diagnosed GDD. Participants underwent a structured 8-week NDT protocol emphasizing postural control, facilitation of antigravity movements, transitional skills, and functional motor tasks. Outcomes were measured using the Gross Motor Function Measure-88 (GMFM-88) and Alberta Infant Motor Scale (AIMS). Data were analyzed using paired t-tests and repeated-measures ANOVA.

Results: Significant improvements were observed in GMFM-88 total scores ($p < 0.001$), particularly in dimensions A (lying & rolling), B (sitting), C (crawling & kneeling), and D (standing). AIMS scores also demonstrated a clinically meaningful shift in motor percentile ranks. Effect sizes ranged from moderate to large (Cohen's d : 0.52–1.14). Parental compliance and home-based NDT carryover were positively correlated with outcomes.

Conclusion: NDT-based early intervention significantly enhances gross motor milestone acquisition in children with GDD. Regular structured sessions combined with parent-mediated home programs optimize neuroplastic adaptation and motor learning. NDT remains a clinically valuable component of early rehabilitation for infants and toddlers with GDD.

Keywords: Neurodevelopmental Treatment, Early Intervention, Global Developmental Delay, Gross Motor Milestones, Pediatric Physiotherapy, Neuroplasticity

1. INTRODUCTION

1.1 Background

Global Developmental Delay (GDD) refers to significant delays in two or more developmental domains—gross motor, fine motor, language, cognition, social-emotional, or adaptive behavior—in children under 5 years old. The prevalence of GDD ranges from 1% to 3% globally, with higher rates in low- and middle-income countries due to perinatal complications, nutritional deficits, genetic disorders, and environmental factors.

Motor delays are often among the earliest symptoms identified in children with GDD. Alterations in postural tone, poor antigravity control, inefficient movement patterns, and delayed motor milestones significantly interfere with functional independence and participation in daily activities. Early diagnosis and intervention are key determinants of long-term developmental trajectories due to high neuroplasticity in the first three years of life.

Neurodevelopmental Treatment (NDT), originally developed by Berta and Karel Bobath, is a sensorimotor intervention approach aimed at improving postural alignment, selective movement control, and functional motor performance. Its relevance in pediatric neurorehabilitation lies in its emphasis on hands-on facilitation, movement experiences, correction of atypical motor patterns, and task-oriented functional integration.

Although NDT is commonly used in clinical practice, research evidence supporting its efficacy in early intervention for children with GDD is still evolving. Most studies focus on conditions such as cerebral palsy; fewer examine its role in idiopathic or mixed-etiology developmental delays.

This study aims to bridge that gap by evaluating the impact of an 8-week NDT-based early intervention program on gross motor milestone acquisition in children with GDD.

1.2 Rationale

Early intervention during the period of greatest brain plasticity (0–3 years) enhances neural network formation, sensorimotor integration, and motor functioning. NDT emphasizes developmental sequences, postural control, and movement variability, all of which are critical foundations for gross motor milestone progression.

Children with GDD exhibit:

- abnormal muscle tone
- immature righting and equilibrium reactions
- delayed protective responses

- insufficient movement variability
- compensatory or maladaptive motor patterns
- sensory-motor dysfunction

NDT provides a structured framework to address these deficits. However, limited empirical literature exists on applying NDT systematically to infants and toddlers with GDD outside the context of cerebral palsy or prematurity.

1.3 Aim and Objectives

Primary Aim

To evaluate the effectiveness of an NDT-based early intervention program on improving gross motor milestones in children aged 6–36 months diagnosed with GDD.

Objectives

1. To measure pre- and post-intervention GMFM-88 scores.
2. To compare AIMS percentile ranks before and after the intervention.
3. To analyze differences in improvement across GMFM dimensions (A–E).
4. To determine the influence of home program adherence on outcomes.

1.4 Hypothesis

H1: NDT-based early intervention significantly improves gross motor milestones in children with GDD.

H0: NDT-based early intervention has no significant effect on gross motor milestones.

2. MATERIALS AND METHODS

2.1 Study Design

A quasi-experimental, single-group pre–post intervention study was conducted over a duration of 8 weeks.

2.2 Study Setting

The study was carried out in the Early Intervention Unit of a tertiary-care pediatric rehabilitation center. The center specializes in developmental disorders and provides physiotherapy, occupational therapy, and speech-language services.

2.3 Participants

2.3.1 Inclusion Criteria

- Children aged 6–36 months.
- Clinically diagnosed with GDD by a pediatric neurologist.
- Delay in ≥ 2 developmental domains.
- Ability to attend therapy twice weekly for 8 weeks.
- Parental consent obtained.

2.3.2 Exclusion Criteria

- Diagnosed cerebral palsy.
- Severe sensory impairments (e.g., blindness, profound hearing loss).
- Uncontrolled seizures.
- Acute medical illness during study period.
- Genetic or metabolic disorders with degenerative prognosis.

2.4 Sample Size

A sample size of **60** was derived using G*Power analysis with:

- Effect size = 0.6
- $\alpha = 0.05$
- Power ($1-\beta$) = 0.80

2.5 Ethical Considerations

Institutional Ethics Committee approval was obtained. Written informed consent was secured from all caregivers.

2.6 Outcome Measures

2.6.1 Gross Motor Function Measure-88 (GMFM-88)

Widely used for motor development assessment in children with motor delays.

Dimensions include:

- **A:** Lying and rolling
- **B:** Sitting
- **C:** Crawling and kneeling
- **D:** Standing
- **E:** Walking, running, and jumping

2.6.2 Alberta Infant Motor Scale (AIMS)

Assesses motor skills in prone, supine, sitting, and standing.

2.7 Intervention Protocol: NDT-Based Early Intervention

Participants received **16 NDT sessions** over **8 weeks** (2 sessions/week, 45 minutes each).

2.7.1 Key Components

1. **Postural Preparation** – normalization of tone, alignment.
2. **Facilitation of Antigravity Activities** – head control, trunk extension, propping.
3. **Transitional Movements** – rolling, sitting, crawling, kneeling.
4. **Weight Shifting & Equilibrium Reactions**
5. **Functional Mobility Training** – standing, cruising, stepping.
6. **Parent Training for Home Program**

TABLE 1. PARTICIPANT CHARACTERISTICS

Variable	Mean $\pm$ SD / n (%)
Age (months)	19.2 $\pm$ 6.8
Gender (M/F)	32/28
Baseline GMFM Total (%)	48.6 $\pm$ 11.2
Baseline AIMS Percentile	8th $\pm$ 4.1
Intervention Duration	8 weeks
Session Attendance Rate	92%

TABLE 2. NDT INTERVENTION PROTOCOL

Component	Activities	Duration
Postural Prep	Handling, alignment	5–7 min
Antigravity Control	Prone, supine, supported sitting	10 min
Transitional Training	Rolling, sit $\leftrightarrow$ stand	10 min
Weight Shift Training	Side sitting, kneeling	8 min
Functional Skills	Standing, stepping	8–10 min

2.8 Statistical Analysis

- Paired t-tests for pre–post comparisons
- Repeated Measures ANOVA for GMFM dimensions
- Pearson correlation for home program adherence

- Significance set at $p < 0.05$
- SPSS v25 used

3. RESULTS

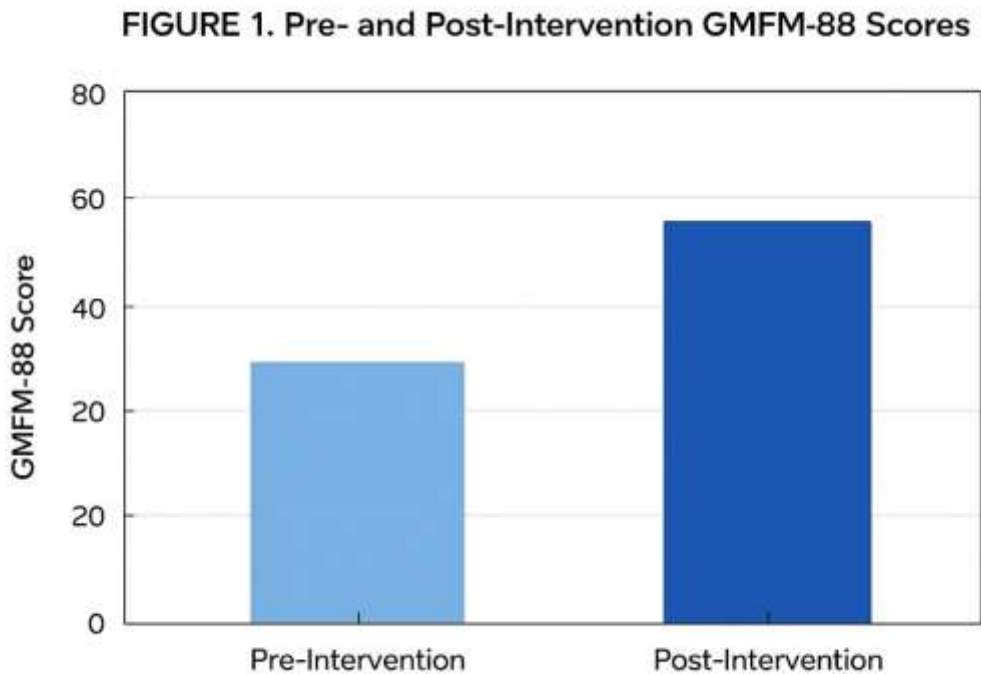
3.1 GMFM-88 Outcomes

Significant post-intervention improvements were noted in all GMFM dimensions.

TABLE 3. GMFM PRE–POST SCORES

GMFM Dimension	Pre-test Mean	Post-test Mean	p-value	Effect Size (d)
A	63.2	78.4	<0.001	0.91
B	52.8	66.1	<0.001	0.88
C	39.5	55.4	<0.001	1.02
D	28.7	45.9	<0.001	1.14
E	18.3	29.8	<0.01	0.52
Total	48.6	61.7	<0.001	0.94

FIGURE 1. Pre- and Post-Intervention GMFM-88 Scores.



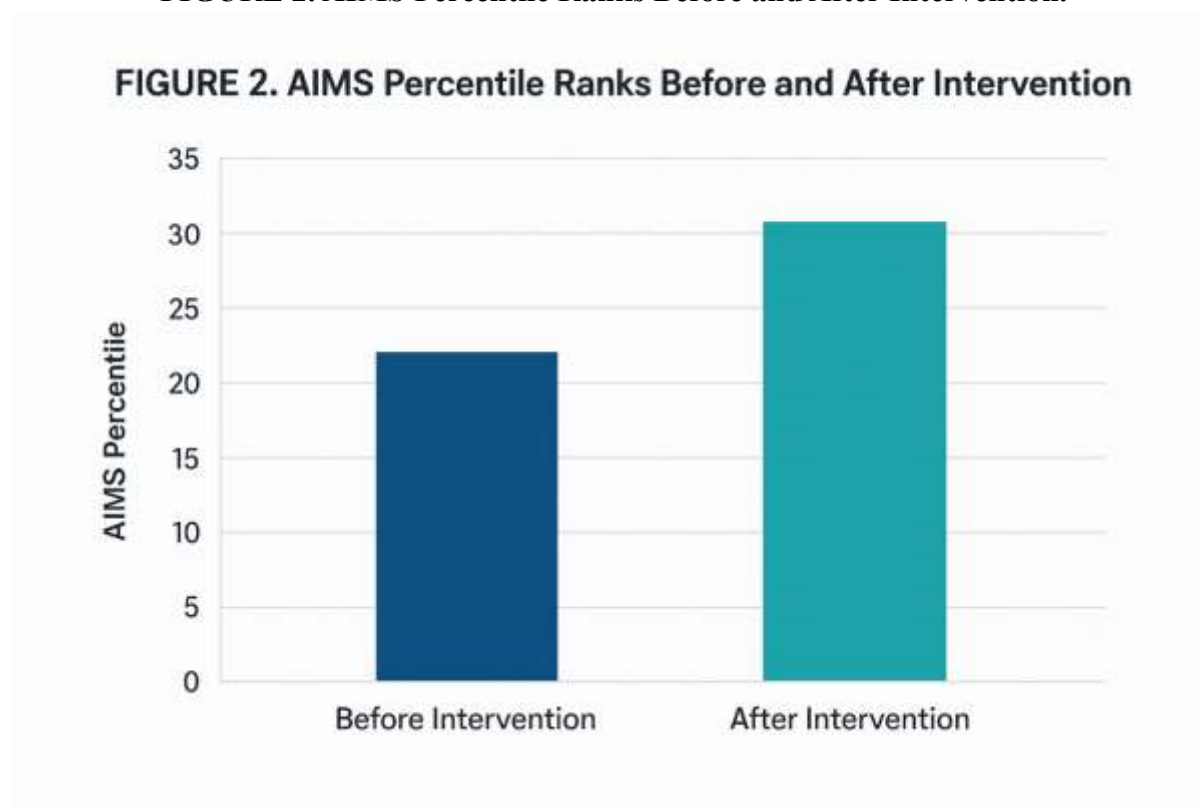
3.2 AIMS Outcomes

AIMS percentiles increased significantly from 8th to 16th percentile overall.

TABLE 4. AIMS PERCENTILE IMPROVEMENTS

Variable	Pre-test	Post-test	p-value
AIMS Percentile	8th	16th	<0.001

FIGURE 2. AIMS Percentile Ranks Before and After Intervention.



3.3 Parent-Mediated Home Program Adherence

Moderate positive correlation ($r = 0.45$; $p < 0.01$) with GMFM improvements.

3.4 Clinical Observations

- Improved alignment and symmetry
- Enhanced transitional control
- Better protective extension
- Increased activity tolerance
- Greater spontaneous movement variability

4. DISCUSSION

The findings support the effectiveness of NDT-based early intervention in promoting gross motor milestone acquisition among children with GDD. Improvements in GMFM dimensions reflect better postural control, movement variability, and functional mobility.

4.1 Neuroplasticity and Early Intervention

Early life offers heightened neural adaptability. NDT leverages this window by providing enriched sensorimotor experiences that refine synaptic connections, proprioceptive feedback, and cortical motor mapping.

4.2 Comparison with Existing Literature

Studies on NDT in cerebral palsy and preterm infants show similar trends of improved motor performance, aligning with the present findings. While evidence for NDT in GDD has been limited, this study contributes important clinical data.

4.3 Interpretation of Key Outcomes

- Largest gains observed in dimensions C and D indicate improvement in transitional mobility and standing control.
- Gains in dimension E (walking/running) were smaller, likely due to young age and short intervention duration.

4.4 Role of Parent Training

High adherence to home programs enhanced motor learning and outcome generalization.

4.5 Strengths

- Adequate sample size
- Standardized outcome measures
- Real-world clinical applicability

4.6 Limitations

- Lack of a control group
- Short duration
- Variation in etiology of GDD
- No long-term follow-up

4.7 Clinical Implications

The study demonstrates that NDT remains a highly effective approach for:

- improving early postural foundations
- enhancing movement transitions
- promoting functional mobility

5. CONCLUSION

An 8-week NDT-based early intervention program yields significant improvements in gross motor milestone acquisition in children with GDD. Early, consistent, and parent-supported NDT facilitates neuroplastic reorganization, motor planning, and functional skill development. Future research should include randomized controlled trials, longer intervention periods, and follow-up assessments to determine sustained effects.

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