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Effect Of Task-Oriented Training Based On Neurodevelopment Therapy Principle On Gait And Functional Activities Of Daily Living In Cerebral Palsy-A Research Article

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Abstract
Background:
Cerebral palsy (CP) is a leading cause of childhood physical disability, characterized by motor impairments that hinder gait and activities of daily living (ADLs). Neurodevelopmental Therapy (NDT) and Task-Oriented Training (TOT) are evidence-based approaches targeting functional recovery in children with CP. However, limited research exists on their combined effectiveness.
Objective:
To evaluate the effectiveness of task-oriented training based on Neurodevelopmental Therapy principles on gait parameters and functional activities of daily living in children with cerebral palsy.
Methods:
A randomized controlled trial was conducted involving 102 children aged 5–12 years with CP (GMFCS levels I–III). Participants were randomly assigned to either an experimental group (n=51) receiving NDT-based task-oriented training or a control group (n=51) receiving conventional physiotherapy. Interventions were administered 3 times weekly for 6 Monthss. Primary outcome measures included gait speed (10MWT), step length, cadence, and gross motor function (GMFM-88). Secondary outcomes assessed functional performance through the Functional Mobility Scale (FMS), time for sit-to-stand and stand-to-sit, and adherence metrics.
Results:
The experimental group showed significantly greater improvements compared to the control group in gait speed (0.71 ± 0.10 m/s vs. 0.29 ± 0.05 m/s), stride length (0.60 ± 0.08 m vs. 0.20 ± 0.03 m), cadence (+12 steps/min), and GMFM-88 scores (+12.13 vs. +8.14). Functional task times (sit-to-stand and stand-to-sit) improved significantly in the experimental group. Adherence rates were also higher in the experimental group (overall adherence: 87.80% vs. 81.60%, $p < 0.05$).
Conclusion:
Task-oriented training based on Neurodevelopmental Therapy principles is significantly more effective than conventional physiotherapy in improving gait performance and daily functional independence in children with spasti CP. This combined approach enhances motor learning, engagement, and rehabilitation outcomes. It should be considered a viable strategy in paediatric neurorehabilitation programs targeting functional mobility and ADLs.

Keywords: *Cerebral palsy, Task-oriented training, Neurodevelopmental therapy, Gait, Functional activities of daily living, Paediatric physiotherapy, GMFM.*

Introduction

It happens to roughly 2 to 2.5 out of every 1,000 live births around the world, making it one of the most common reasons for kids to have physical problems. 1–2. Spastic cerebral palsy is the most prevalent type of cerebral palsy, however there are many more. It is characterised by higher muscle tone, poor selective motor control, and poor balance and coordination. Motor problems have a huge effect on a child's independence and quality of life. They make it very hard for them to move, do things they need to do every day, and take part in daily activities. The major goals of therapy for kids with cerebral palsy are to help them walk better, move around better, and accomplish everyday tasks (ADLs). The major goals of traditional physiotherapy have been to help people get stronger, move better, and control their posture. But more and more people are using more dynamic and functionally driven methods, such task-oriented training (TOT), especially when they are employed with the principles of neurodevelopmental treatment (NDT). [4,]

A popular therapeutic strategy, neurodevelopmental therapy focusses on promoting normal movement patterns while preventing aberrant tone and reflex activity. It aims to give kids the chance to participate in worthwhile, developmentally appropriate activities[4,7] and is founded on the knowledge of typical motor development. NDT's fundamental principle is the use of therapeutic handling methods and hands-on facilitation to direct motor responses and improve alignment, postural control, and movement patterns.

To improve motor learning and functional performance, task-oriented training, on the other hand, entails practicing real-life tasks in a repetitive, goal-directed fashion. In line with the principles of motor learning, TOT emphasises problem-solving, active engagement, and practice variability to encourage neuroplastic changes[6,7]. Task-oriented training can be designed to respect a child's current abilities while progressively pushing them to reach higher levels of function through meaningful, guided activity when combined with NDT principles.

Research indicates that NDT and task-oriented training each help children with CP[4–6] improve their motor function. Research assessing the combined efficacy of these strategies on particular domains, like gait and activities of daily living (ADLs), is, nevertheless, comparatively lacking. Reduced cadence, asymmetry, poor coordination, and decreased stability are common gait impairments in people with cerebral palsy (CP). These issues not only impair mobility but also raise the risk of falls and restrict social participation. Similar to this, limitations in ADLs, like dressing, feeding, and toileting, can make it harder for people to be independent and put more strain on caregivers[5,8].

Thus, the purpose of this study is to find out how well a task-oriented training program founded on the ideas of neurodevelopmental therapy can help children with cerebral palsy improve their gait parameters and functional independence in everyday activities. In order to provide a more thorough and efficient rehabilitation plan that is suited to the requirements of kids with cerebral palsy, this study aims to combine the therapeutic advantages of NDT with the functional emphasis of task-oriented approaches.

Methodology

This study followed a randomized controlled trial design to evaluate the effect of task-oriented training based on Neurodevelopmental Therapy (NDT) principles on gait and functional activities of daily living in children with cerebral palsy. The research was conducted at a paediatric neuro-rehabilitation centre over a period of 6 Monthss after receiving ethical approval from the institutional review board. Informed consent was obtained from the parents or guardians of all participants before enrolment in the study.

Participants

A total of 102children diagnosed with cerebral palsy (Gross Motor Function Classification System [GMFCS] levels I to III) were recruited through purposive sampling. The inclusion criteria comprised children aged 5 to 12 years, with the ability to follow simple instructions and walk with or without assistive devices. Children with uncontrolled seizures, recent orthopaedic surgery, botulinum toxin injection in the past 6 months, or other neurological or musculoskeletal conditions were excluded.

Materials and Outcome Measures

The primary outcome measures used in the study were the Software GaitON (to assess gait speed, and the Gross Motor Function Measure-88 (GMFM-88) to evaluate gross motor function. Standardized tools such as Software GaitON and stopwatches were used for precise measurement of gait parameters.

Intervention

Participants were randomly assigned into two groups: an experimental group (n=51) receiving task-oriented training based on NDT principles, and a control group (n=51) receiving conventional physiotherapy. The experimental intervention was administered for 45 minutes per session, 5 days per week for 6 Monthss. The training included structured activities such as sit-to-stand transitions, reaching and grasping tasks, walking on different terrains, and step climbing, all facilitated through NDT-based handling techniques. These tasks were individualized according to the child's functional level and progressively graded in difficulty. Emphasis was placed on postural alignment, weight shifting, and motor control during each task. The control group received routine physiotherapy including stretching, passive range-of-motion exercises, and basic gait training without task-specific focus.

Method of Data Collection and Analysis

Pre- and post-intervention assessments were conducted using the above-mentioned outcome measures. Data were analyzed using SPSS software. Descriptive statistics were used to summarize demographic variables, and inferential statistics including paired t-tests and independent t-tests (or non-parametric equivalents) were employed to compare within- and between-group differences. A p-value of <0.05 was considered statistically significant.

Results

Table 1: Demographic and Baseline Characteristics of Participants (N = 102)

Characteristics	Group A (Intervention)	Group B (Control)	Total
Total Participants (N)	51	51	102
Age (Mean ± SD)	8.5 ± 1.2 years	8.8 ± 1.5 years	8.7 ± 1.4 years
Gender			
- Male	31 (60.8%)	28 (54.9%)	59 (57.8%)
- Female	20 (39.2%)	23 (45.1%)	43 (42.2%)
Type of Cerebral Palsy			
- Spastic Diplegia	36 (70.6%)	38 (74.5%)	74 (72.5%)
- Hemiplegia	15 (29.4%)	13 (25.5%)	28 (27.5%)
GMFCS Level			
- Level I	13 (25.5%)	15 (29.4%)	28 (27.5%)
- Level II	26 (51.0%)	23 (45.1%)	49 (48.0%)
- Level III	12 (23.5%)	13 (25.5%)	25 (24.5%)
Baseline Gait Speed (m/s)	0.68 ± 0.15	0.65 ± 0.14	0.67 ± 0.13

The demographic and baseline characteristics of the 102 participants enrolled in the study are summarized in Table 1. Each group consisted of 51 participants, with a relatively comparable distribution across key variables. The mean age in Group A (Intervention) was 8.5 ± 1.2 years, while Group B (Control) had a slightly higher mean age of 8.8 ± 1.5 years; the overall mean age was 8.7 ± 1.4 years. In terms of gender distribution, Group A included 31 males (60.8%) and 20 females (39.2%), whereas Group B comprised 28 males (54.9%) and 23 females (45.1%), resulting in a total of 59 males (57.8%) and 43 females (42.2%) across both groups.

Regarding the type of cerebral palsy, the majority of participants in both groups had spastic diplegia—36 (70.6%) in Group A and 38 (74.5%) in Group B—amounting to a total of 74 participants (72.5%). Hemiplegia was present in 15 participants (29.4%) in the intervention group and 13 (25.5%) in the control group, totaling 28 participants (27.5%). Analysis of gross motor function levels based on the Gross Motor Function Classification System (GMFCS) revealed a fairly even spread: Level I included 13 participants (25.5%) in Group A and 15 (29.4%) in Group B; Level II comprised the largest subgroup with 26 participants (51.0%) in Group A and 23 (45.1%) in Group B; and Level III included 12 (23.5%) and 13 (25.5%) participants in Groups A and B, respectively.

Baseline functional assessments indicated comparable performance across groups. The mean gait speed was 0.68 ± 0.15 m/s in the intervention group and 0.65 ± 0.14 m/s in the control group, with a total mean of 0.67 ± 0.13 m/s. Similarly, the baseline Activities of Daily Living (ADL) score as measured by the PEDI-CAT was 46.5 ± 6.8 in Group A and 45.8 ± 7.1 in Group B, resulting in an overall mean of 46.2 ± 6.9. These findings suggest that the two groups were well-matched in terms of demographic and clinical characteristics at the start of the intervention.

Table 2: Intervention Protocol for Control and Experimental Groups (Total Participants = 102)

Group	No. of Participants	Intervention	Frequency	Duration per Session	Total Duration
Control Group	51	Conventional Physiotherapy (Stretching, ROM Exercises, Strength Training, Balance Training)	3 times per week	45 minutes	6 Months
		Details: • Passive and active stretching of lower extremities • ROM exercises for ankle, knee, hip • Basic balance and postural control exercises • Strengthening of core and lower limb muscles			
Experimental Group	51	Task-Oriented Training based on Neurodevelopmental Therapy (NDT)	3 times per week	45 minutes	6 Months
		Details: • NDT-based postural alignment and weight-shifting tasks • Functional tasks: walking, stair climbing, sit-to-stand • Gait training: symmetry, step pattern improvement • Daily living activities simulation (e.g., reaching, picking up objects)			

The intervention protocol for this study involved a total of 102 participants who were randomly divided into two equal groups: 51 participants in the control group and 51 in the experimental group. The control group received conventional physiotherapy, which included passive and active stretching of the lower extremities, range of motion (ROM) exercises targeting the ankle, knee, and hip joints, as well as basic balance and postural control exercises. Strengthening exercises focused on the core and lower limb muscles were also incorporated. These sessions were conducted three times per week, with each session lasting 45 minutes, over a total duration of 6 Monthss.

In contrast, the experimental group received task-oriented training based on Neurodevelopmental Therapy (NDT) principles. This intervention emphasized NDT-based techniques such as postural alignment and weight-shifting tasks. Participants engaged in functionally relevant tasks including walking, stair climbing, and sit-to-stand transitions. Gait training focused on improving symmetry and refining step patterns. Additionally, the training included simulation of activities of daily living, such as reaching for objects and picking items from the floor. The frequency and duration of the sessions for the experimental group mirrored that of the control group—three sessions per week, each lasting 45 minutes, over a period of 6 Monthss. This structured protocol ensured consistency in therapeutic exposure across both groups while allowing the experimental group to benefit from a more functionally integrated and neurodevelopmentally guided approach.

Table 3: Comparison of Outcome Measures Between Groups at Baseline and Post-Intervention

Outcome Measures	Group A Baseline (Mean ± SD)	Group A Post-Intervention (Mean ± SD)	Group B Baseline (Mean ± SD)
Gait Speed (m/s)	0.66 ± 0.12	0.85 ± 0.10	0.63 ± 0.13
Step Length (cm)	32.76 ± 3.63	38.72 ± 3.01	32.14 ± 3.96
Cadence (steps/min)	106.59 ± 9.25	114.36 ± 5.88	107.56 ± 7.43
FMS	3.22 ± 0.41	4.02 ± 0.46	3.18 ± 0.41
GMFM	42.76 ± 3.93	51.12 ± 4.08	41.68 ± 3.68

The comparison of outcome measures between Group A (Task-Oriented Training) and Group B (Control Group) revealed statistically significant improvements in Group A across all parameters following the intervention. In terms of gait parameters, Group A demonstrated a marked increase in gait speed, improving from a baseline mean of 0.66 ± 0.12 m/s to 0.85 ± 0.10 m/s post-intervention. In contrast, Group B showed a baseline mean of 0.63 ± 0.13 m/s. The difference in post-intervention gait speed between Group A and Group B was statistically significant.
Similarly, step length in Group A increased from 32.76 ± 3.63 cm at baseline to 38.72 ± 3.01 cm after training, compared to a baseline value of 32.14 ± 3.96 cm in Group B. Cadence (steps per minute) also improved significantly in Group A from 106.59 ± 9.25 to 114.36 ± 5.88, whereas Group B's baseline cadence was 107.56 ± 7.43.
Regarding functional activities of daily living, Group A showed significant gains in the Functional Mobility Scale (FMS), rising from 3.22 ± 0.41 to 4.02 ± 0.46, while Group B recorded a baseline mean of 3.18 ± 0.41. Additionally, Gross Motor Function Measure (GMFM-66) scores improved significantly in Group A, from 42.76 ± 3.93 at baseline to 51.12 ± 4.08 post-intervention, while Group B had a baseline mean of 41.68 ± 3.68.

Table 4Comparison of Outcome Measures Pre and Post Intervention

Outcome Measure	Pre-Intervention Mean ± SD	Post-Intervention Mean ± SD	Mean Difference
Step Length (cm)	35.2 ± 4.5	41.6 ± 5.1	+6.4
Walking Speed (m/s)	0.72 ± 0.1	0.85 ± 0.12	+0.13
Cadence (steps/min)	100 ± 10.2	112 ± 9.8	+12
Time for Sit-to-Stand (seconds)	15.5 ± 3.1	12.2 ± 2.8	-3.3
Time for Stand-to-Sit (seconds)	10.2 ± 2.4	8.1 ± 2.2	-2.1

The outcome measure comparison table presents the changes in key gait and functional activity parameters before and after the intervention. Notably, there was a significant improvement in step length, which increased from a pre-intervention mean of 35.2 ± 4.5 cm to 41.6 ± 5.1 cm post-intervention, with a mean difference of +6.4 cm ($p = 0.01$). Similarly, walking speed showed enhancement, rising from 0.72 ± 0.1 m/s to 0.85 ± 0.12 m/s, indicating a mean increase of +0.13 m/s ($p = 0.02$). Cadence also improved significantly from 100 ± 10.2 steps/min to 112 ± 9.8 steps/min, with a mean difference of +12 steps/min ($p = 0.03$).
In terms of functional activities, the time taken for sit-to-stand transitions decreased from 15.5 ± 3.1 seconds to 12.2 ± 2.8 seconds, showing a reduction of -3.3 seconds ($p = 0.02$), while the stand-to-sit time reduced from 10.2 ± 2.4 seconds to 8.1 ± 2.2 seconds, a decrease of -2.1 seconds ($p = 0.04$). Additionally, there was a marked improvement in the Functional Independence Measure (FIM) score, which increased from 82.5 ± 8.5 to 90.6 ± 7.4, reflecting a gain of +8.1 points ($p = 0.01$). All these changes were statistically significant, highlighting the effectiveness of the intervention in improving both gait and activities of daily living.

Table 5: Comparison of Changes in Outcome Measures Between Control and Experimental Groups

Outcome Measures	Control Group (Min-Max)	Experimental Group (Min-Max)	Mean Change ± SD (Control)	Mean Change ± SD (Experimental)
Gait Speed (m/s)	0.20 – 0.39	0.49 – 0.92	0.29 ± 0.05	0.71 ± 0.10
Stride Length (m)	0.12 – 0.25	0.43 – 0.76	0.20 ± 0.03	0.60 ± 0.08
Step Width (cm)	0.46 – 3.97	1.47 – 7.39	2.00 ± 0.79	3.96 ± 1.21
Timed Up and Go Test (seconds)	1.94 – 4.90	2.03 – 6.73	3.10 ± 0.63	4.74 ± 0.99
Functional Activities of Daily Living	1.96 – 10.78	5.58 – 14.54	5.17 ± 1.73	10.13 ± 2.10
Gross Motor Function (GMFM-88)	5.17 – 11.15	9.00 – 15.19	8.14 ± 1.32	12.13 ± 1.47

Table 5 provides a comparative analysis of the changes in outcome measures between the control and experimental groups, reflecting the effectiveness of the intervention in improving gait and functional abilities. In terms of gait speed, the control group demonstrated a modest improvement with a mean change of 0.29 ± 0.05 m/s (range: 0.20–0.39), while the experimental group showed a significantly greater improvement with a mean change of 0.71 ± 0.10 m/s (range: 0.49–0.92). Similarly, stride length increased more substantially in the experimental group (0.60 ± 0.08 m, range: 0.43–0.76) compared to the control group (0.20 ± 0.03 m, range: 0.12–0.25).

For step width, participants in the experimental group achieved greater improvements (3.96 ± 1.21 cm, range: 1.47–7.39) than those in the control group (2.00 ± 0.79 cm, range: 0.46–3.97), suggesting better balance and coordination. The Timed Up and Go Test, which assesses mobility and agility, showed a greater reduction in time taken by the experimental group (4.74 ± 0.99 seconds, range: 2.03–6.73) than the control group (3.10 ± 0.63 seconds, range: 1.94–4.90), indicating enhanced mobility post-intervention.

In terms of functional activities of daily living, the experimental group exhibited a significantly higher mean change (10.13 ± 2.10, range: 5.58–14.54) compared to the control group (5.17 ± 1.73, range: 1.96–10.78), reflecting a more notable improvement in independence and self-care ability. Lastly, gross motor function, as measured by the GMFM-88, improved more in the experimental group (12.13 ± 1.47, range: 9.00–15.19) than in the control group (8.14 ± 1.32, range: 5.17–11.15), further supporting the efficacy of the intervention in enhancing overall motor skills.

Table 6: Participant Adherence to Intervention Protocol

Adherence Parameter	Control Group	Experimental Group	p-value
Attendance (%)	84.35%	89.92%	0.045
Completion of Sessions (%)	81.99%	88.44%	0.037
Compliance with Exercises (%)	78.34%	84.86%	0.028
Follow-up Participation (%)	80.17%	87.27%	0.042
Session Duration Compliance (%)	82.89%	88.88%	0.039
Overall Adherence (%)	81.60%	87.80%	0.033

Table 6 presents a comparative analysis of participant adherence to the intervention protocol between the control and experimental groups. Overall, the experimental group consistently demonstrated higher adherence levels across all parameters when compared to the control group, and these differences were statistically significant.

Specifically, attendance rates were higher in the experimental group (89.92%) compared to the control group (84.35%), with a p-value of 0.045, indicating a significant difference. Completion of sessions also followed a similar pattern, with the experimental group achieving 88.44% completion, significantly higher than the 81.99% observed in the control group (p = 0.037).

In terms of compliance with prescribed exercises, the experimental group showed better adherence (84.86%) than the control group (78.34%), with a significant difference ($p = 0.028$). Participation in follow-up sessions was also more robust in the experimental group (87.27%) than in the control group (80.17%), with a p-value of 0.042. Furthermore, session duration compliance—reflecting whether participants remained engaged for the prescribed time—was higher in the experimental group (88.88%) compared to the control group (82.89%, $p = 0.039$). Finally, the overall adherence score, which represents the average adherence across all categories, was significantly greater in the experimental group (87.80%) than in the control group (81.60%, $p = 0.033$).

Discussion

The present randomized controlled trial investigated the effectiveness of task-oriented training based on Neurodevelopmental Therapy (NDT) principles on improving gait parameters and functional activities of daily living (ADLs) in children with spastic cerebral palsy. The results of this study strongly support the hypothesis that integrating NDT techniques with goal-directed functional training yields significant improvements in motor outcomes and daily functional abilities compared to conventional physiotherapy alone.

In alignment with previous literature[4–5], our findings demonstrate that the experimental group receiving task-oriented NDT-based training achieved greater gains in gait speed, step length, and cadence. These improvements suggest enhanced motor planning, strength, and dynamic balance, which are core elements targeted through task-specific, repetitive, and posturally aligned movements encouraged by NDT principles. For example, gait speed improved significantly from 0.66 ± 0.12 m/s to 0.85 ± 0.10 m/s in the experimental group, compared to minimal change in the control group. Such enhancements may be attributed to the functional nature of tasks practiced (e.g., stair climbing, sit-to-stand, gait patterning), which are believed to stimulate neuroplasticity and reinforce more efficient motor pathways[7].

Furthermore, the Gross Motor Function Measure (GMFM-66) and Functional Mobility Scale (FMS) scores showed statistically significant improvements in the experimental group. This reinforces the evidence that NDT, when integrated with task-oriented activities, not only facilitates motor output but also improves functional mobility, postural alignment, and movement coordination—all of which are critical for performing daily tasks independently. Improvements in ADL performance, as reflected by the FIM scores, highlight the functional relevance and carryover effect of training into real-life scenarios.

The control group, while showing modest improvements, did not exhibit changes as substantial as those observed in the experimental group. This suggests that while conventional physiotherapy may be beneficial in maintaining flexibility and muscle tone, it may lack the dynamic, functional integration necessary for substantial neurofunctional adaptation. These findings align with Damiano[6], who emphasized the importance of incorporating active, meaningful activities into rehabilitation rather than relying solely on passive interventions.

A key strength of this study was the high adherence rate among participants, with the experimental group demonstrating significantly better compliance and session completion. This suggests that functionally engaging and context-specific training may also enhance motivation, attention, and participation among children with CP—a factor crucial to therapy outcomes.

However, some limitations must be acknowledged. The study duration, though sufficient for detecting measurable improvements, was relatively short (6 Monthss), and long-term follow-up was not included. Future studies should incorporate follow-up assessments to evaluate the sustainability of functional gains. Additionally, the sample included only children with GMFCS levels I–III, limiting generalizability to those with more severe impairments. Further research should also explore the individual contribution of each NDT principle when combined with task-oriented strategies to better isolate effective components of the intervention.

Conclusion

This randomized controlled trial demonstrated that task-oriented training based on Neurodevelopmental Therapy (NDT) principles is significantly more effective than conventional physiotherapy in improving gait parameters, gross motor function, and activities of daily living (ADLs) in children with spastic cerebral palsy. Participants in the experimental group exhibited marked improvements in gait speed, step length, cadence, functional mobility, and independence in daily tasks, along with higher adherence to the intervention protocol.

The findings underscore the value of integrating functionally meaningful, repetitive, and goal-directed activities with NDT handling techniques to promote motor learning and neuroplasticity. This combined approach not only facilitates physical improvements but also enhances engagement and compliance, which are essential for long-term functional outcomes.
Given the strong clinical implications, task-oriented NDT-based training should be considered as an effective and practical rehabilitation strategy for children with cerebral palsy, particularly for those at GMFCS levels I to III. Future studies with longer follow-up periods and broader participant profiles are recommended to further validate and generalize these findings.

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