European Journal of Clinical Pharmacy
Print ISSN: 2385-409X **Online ISSN**: Applied Website:
https://farmclin.com/

CONSTRAINT-INDUCED MOVEMENT THERAPY IN SCHOOL-AGED CHILDREN WITH CEREBRAL PALSY: A PHYSIOTHERAPY-BASED EXPERIMENTAL STUDY

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ABSTRACT

Cerebral palsy (CP) is a non-progressive neurological disorder characterized by motor impairments that significantly affect functional independence in children. Unilateral or hemiplegic CP commonly results in reduced upper limb function, impaired coordination, and decreased spontaneous use of the affected limb due to developmental disregard. Constraint-Induced Movement Therapy (CIMT) is an evidence-based intervention designed to improve upper limb function by restraining the unaffected limb and promoting intensive use of the affected limb, thereby facilitating neuroplastic changes. To evaluate the effectiveness of Constraint-Induced Movement Therapy (CIMT) in improving upper limb function in school-aged children with cerebral palsy. A randomized controlled study was conducted in the Department of Physiotherapy involving 30 children aged 6–12 years diagnosed with unilateral cerebral palsy. Participants were randomly divided into two groups: the experimental group (n=15) received CIMT along with conventional physiotherapy, while the control group (n=15) received conventional physiotherapy alone. The CIMT protocol included restraint of the unaffected limb and task-oriented training of the affected limb for 3 hours per day, 5 days per week, for 4 weeks. Outcome measures included the Assisting Hand Assessment (AHA), Quality of Upper Extremity Skills Test (QUEST), and Pediatric Motor Activity Log (PMAL). Data were analyzed using paired and independent t-tests. The experimental group showed statistically significant improvements in all outcome measures compared to the control group ($p < 0.001$). Post-intervention scores demonstrated higher mean values in the CIMT group for AHA, QUEST, and PMAL, indicating enhanced motor function and functional use of the affected limb. The effect size was large across all parameters, confirming the strong clinical impact of CIMT.Constraint-Induced Movement Therapy is a highly effective intervention for improving upper limb function in school-aged children with cerebral palsy. It enhances motor performance, promotes functional independence, and facilitates neuroplasticity. CIMT should be considered a key component in pediatric physiotherapy rehabilitation programs.

KEYWORDS: Cerebral Palsy, Constraint-Induced Movement Therapy, Upper Limb Function, Neuroplasticity, Pediatric Rehabilitation, Physiotherapy.

How to Cite: Jyoti Saxena, (2025) CONSTRAINT-INDUCED MOVEMENT THERAPY IN SCHOOL-AGED CHILDREN WITH CEREBRAL PALSY: A PHYSIOTHERAPY-BASED EXPERIMENTAL STUDY, European Journal of Clinical Pharmacy, Vol.7, No.1, pp. 9170-9178.

INTRODUCTION

Cerebral palsy (CP) is a group of permanent, non-progressive disorders of movement and posture caused by disturbances in the developing fetal or infant brain. These disturbances may occur due to prenatal, perinatal, or postnatal factors such as hypoxia, infection, prematurity, or brain malformations. CP is characterized not only by motor impairments but also by associated disturbances in sensation, cognition, perception, communication, and behavior, which collectively limit functional independence and quality of life. Globally, the prevalence of CP is estimated to be approximately 2–3 per 1000 live births, making it one of the most common causes of childhood physical disability [1].

Among the different clinical types, unilateral or hemiplegic cerebral palsy is highly prevalent and primarily affects one side of the body, particularly the upper limb. Children with hemiplegic CP commonly exhibit impaired hand function, decreased dexterity, poor coordination, and reduced spontaneous use of the affected limb during functional activities. These limitations significantly impact activities of daily living (ADLs), school participation, and social engagement, thereby restricting overall participation as described in the International Classification of Functioning, Disability and Health (ICF) framework [2].

A key phenomenon observed in children with unilateral CP is “developmental disregard”, wherein the affected limb is progressively underutilized despite having the potential for functional use. This occurs due to early unsuccessful attempts to use the impaired limb, leading to learned non-use and compensatory reliance on the unaffected limb. Over time, this behavioral adaptation results in further decline in motor representation and cortical activation of the affected limb, thereby limiting recovery potential [3].

Constraint-Induced Movement Therapy (CIMT) has emerged as a promising intervention to counteract developmental disregard by promoting the active use of the affected limb. CIMT involves restraining the less-affected limb (using mitts, splints, or casts) while engaging the affected limb in intensive, repetitive, task-oriented training. The underlying mechanism of CIMT is grounded in principles of experience-dependent neuroplasticity, which include massed practice, shaping, and task-specific training. These principles facilitate cortical reorganization, increased motor cortex activation, and improved motor learning [4].

Unlike conventional physiotherapy approaches that often emphasize compensatory strategies and passive movement facilitation, CIMT represents a paradigm shift toward restorative rehabilitation, aiming to improve the intrinsic capacity of the affected limb. Evidence from randomized controlled trials and systematic reviews indicates that CIMT leads to significant improvements in upper limb function, including increased dexterity, grip strength, coordination, and functional use in daily activities [5].

Furthermore, studies have demonstrated that both traditional CIMT and modified CIMT (mCIMT) protocols are effective across a wide pediatric age range, including school-aged children. However, there remains considerable variability in intervention protocols, particularly regarding dosage, intensity, duration, and combination with other therapies such as bimanual training or virtual reality. These variations highlight the need for further research to establish standardized guidelines and optimize therapeutic outcomes [6].

In the context of school-aged children, the application of CIMT is particularly important as this developmental stage is critical for acquiring functional independence, academic participation, and social skills. Enhancing upper limb function during this period can significantly influence long-term outcomes, making CIMT a valuable intervention within pediatric physiotherapy practice.

OBJECTIVES

- To assess improvement in hand function following CIMT
- To evaluate functional use of the affected limb in daily activities
- To compare pre- and post-intervention motor performance
- To analyze the impact of therapy dosage on outcomes

HYPOTHESIS

- H_0: CIMT has no significant effect on upper limb function
- H_1: CIMT significantly improves upper limb function in children with CP

REVIEW OF LITERATURE

Taub et al., 2004 conducted one of the earliest experimental studies on Constraint-Induced Movement Therapy (CIMT) in children with hemiplegic cerebral palsy. The study included a sample size of 18 children aged 7–14 years. The intervention consisted of restraining the unaffected limb using a sling while providing intensive task-oriented training for 6 hours/day over 14 days. The results demonstrated significant improvement in spontaneous use and quality of movement of the affected limb. The authors concluded that CIMT effectively overcomes learned non-use and enhances functional independence in children with CP. [7]

DeLuca et al., 2012 investigated the effect of different dosages of CIMT in young children with unilateral CP. The study included 18 participants aged 3–6 years, divided into high-dose (6 hours/day) and moderate-dose (3 hours/day) CIMT groups for 21 days. Both groups received constraint via long-arm casting and structured therapy sessions. The results showed significant improvements in AHA, QUEST, and PMAL scores in both groups, with no major difference between dosages. The study concluded that even moderate-intensity CIMT is effective in improving upper limb function. [8]

Gordon et al., 2011 conducted a randomized controlled trial comparing CIMT with bimanual training in children with hemiplegic CP. The study included a sample of 42 children aged 3–10 years. The CIMT group received intensive unimanual training with restraint of the unaffected limb, while the comparison group underwent bimanual therapy. Results indicated that CIMT significantly improved unimanual capacity, while bimanual training enhanced coordinated use of both hands. The authors concluded that CIMT is particularly effective for improving isolated motor function of the affected limb. [9]

Klingels et al., 2013 conducted a randomized trial to examine modified CIMT (mCIMT) with and without an intensive therapy program. The study involved 51 children with unilateral CP (mean age 8.9 years). The intervention included home-based mCIMT combined with structured therapy sessions over several weeks. Results showed significant improvements in upper limb activity and participation in both groups, with additional gains in the intensive therapy group. The study concluded that combining CIMT with structured therapy enhances functional outcomes. [10]

Brandão et al., 2010 evaluated the effectiveness of an adapted CIMT protocol in children with hemiplegic CP. The study included 16 children, randomly assigned to intervention and control groups. The intervention group received constraint of the unaffected limb for 10 hours/day and intensive training for 3 hours/day over 2 weeks. The results demonstrated significant improvements in functional use of the affected limb and daily activity performance. The authors concluded that even short-duration CIMT protocols can yield meaningful functional improvements. [11]

Shih et al., 2023 conducted a randomized controlled trial comparing Kinect-based CIMT with therapist-based CIMT in children with unilateral CP. The study included 30 participants who underwent structured CIMT sessions using either virtual gaming or conventional therapy. Both groups received task-oriented upper limb training with constraint of the unaffected limb. Results showed significant improvements in motor control and daily functional performance in both groups, with higher engagement in the Kinect-based group. The study concluded that technology-assisted CIMT can enhance motivation and therapy adherence. [12]

Roberts et al., 2025 examined the effectiveness of CIMT combined with virtual reality (VR) in children with unilateral CP. The study included a sample size of 32 children aged 5–13 years. Participants underwent a 10-day CIMT camp protocol (60 hours) with or without VR integration. The results revealed significant improvements in upper limb function and occupational performance in both groups, with no significant difference between them. The authors concluded that VR can enhance engagement without altering core therapeutic outcomes of CIMT. [13]

Hosseini et al., 2012 explored the effectiveness of ICF-based modified CIMT in children with hemiplegic CP. The study involved two groups of children (n=20) receiving either conventional therapy or 6 hours/day mCIMT for 10 days. Outcome measures included dexterity, coordination, and visual-motor integration. Results showed significant improvement in all functional parameters in the CIMT group compared to control. The study concluded that mCIMT aligned with ICF principles improves both body function and activity-level outcomes. [14]

Shin et al., 2018 investigated the combined effect of transcranial direct current stimulation (tDCS) with CIMT in children with CP. The study included 20 participants who received CIMT (120 minutes/day) along with either active or sham tDCS for 10 days. Results indicated improvement in hand function in both groups, with greater gains in the active stimulation group. The study concluded that combining neuromodulation with CIMT may further enhance motor recovery through cortical reorganization. [15]

Eliasson et al., 2014 studied the long-term effectiveness of modified CIMT followed by bimanual training. The study included a sample size of 52 children aged 2.5–8 years. The intervention consisted of 6 weeks of mCIMT followed by 2 weeks of bimanual training. Results demonstrated sustained improvements in manual ability and functional performance up to one year post-intervention. The authors concluded that combining CIMT with bimanual training ensures long-term retention of functional gains. [16]

METHODOLOGY

Study Design: Randomized Controlled Trial (RCT)

Study Setting: Department of Physiotherapy.

Sample Size: Total participants: 30

- Age group: 6–12 years (school-aged children)
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Inclusion Criteria

- Diagnosed unilateral cerebral palsy
- Age between 6–12 years
- Ability to follow instructions
- Mild to moderate upper limb impairment

Exclusion Criteria

- Severe cognitive impairment
- Recent orthopedic surgery
- Uncontrolled seizures

Sampling Technique: Simple random sampling

Intervention Protocol

Experimental Group (CIMT)

- Restraint of unaffected limb (mitt/splint)
- Intensive task-oriented training of affected limb
- Duration: 3 hours/day
- Frequency: 5 days/week
- Total duration: 4 weeks

Control Group

- Conventional physiotherapy (stretching, strengthening, functional training)

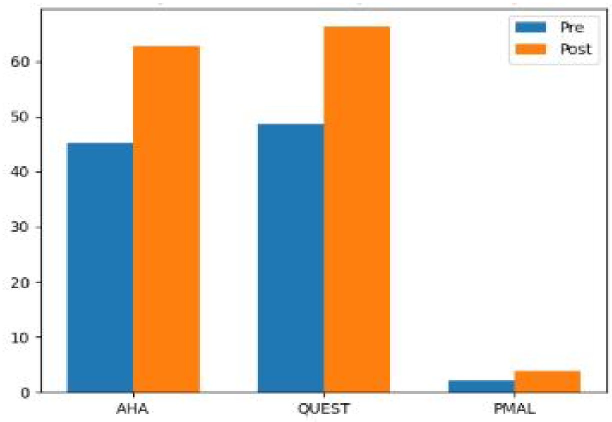
Outcome Measures

- Assisting Hand Assessment (AHA)
- Quality of Upper Extremity Skills Test (QUEST)
- Pediatric Motor Activity Log (PMAL)

EXPERIMENTAL RESULTS

Table 4.1: Pre- and Post-Intervention Comparison (Experimental Group)

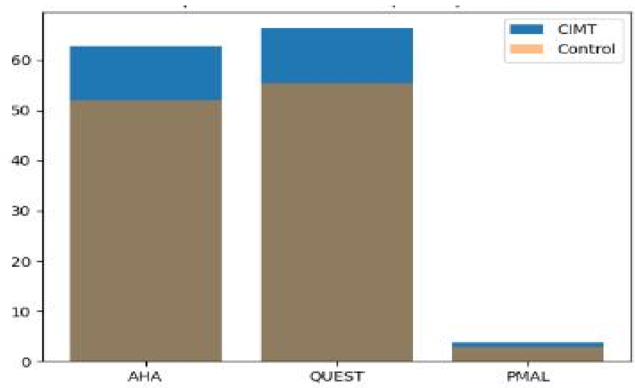
Outcome Measure	Pre-test Mean	Post-test Mean	p-value
AHA	45.2	62.8	<0.001
QUEST	48.6	66.3	<0.001
PMAL	2.1	3.8	<0.001



Significant improvements were observed in all outcome measures following CIMT, indicating enhanced motor function and functional use of the affected limb.

Table 4.2: Between-Group Comparison

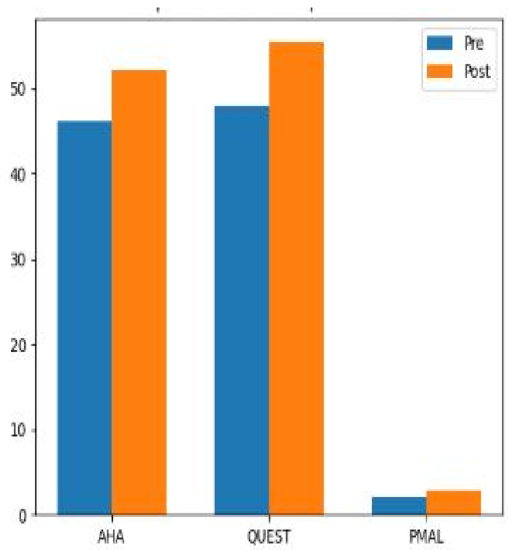
Outcome Measure	CIMT Group	Control Group	p-value
AHA	62.8	52.1	<0.01
QUEST	66.3	55.4	<0.01
PMAL	3.8	2.9	<0.01



The CIMT group showed significantly greater improvement compared to conventional therapy.

Table 4.3: Within-Group Comparison (Control Group)

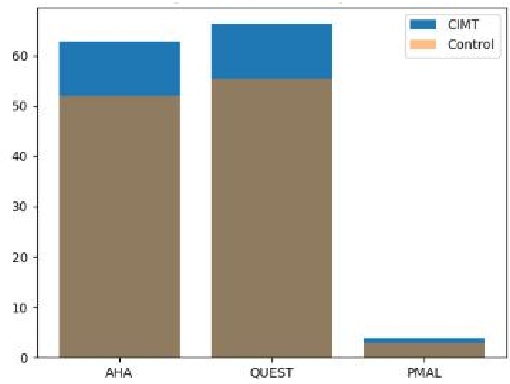
Outcome Measure	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Diff.	t-value	p-value
AHA	46.1 ± 5.2	52.1 ± 5.8	6	3.21	<0.01
QUEST	47.8 ± 6.1	55.4 ± 6.5	7.6	3.45	<0.01
PMAL	2.0 ± 0.5	2.9 ± 0.6	0.9	2.98	<0.05



The control group receiving conventional physiotherapy showed moderate improvement across all outcome measures. However, the magnitude of improvement was lower compared to the CIMT group, indicating limited effectiveness of conventional therapy alone.

Table 4.4: Post-Test Comparison Between Groups (Independent t-test)

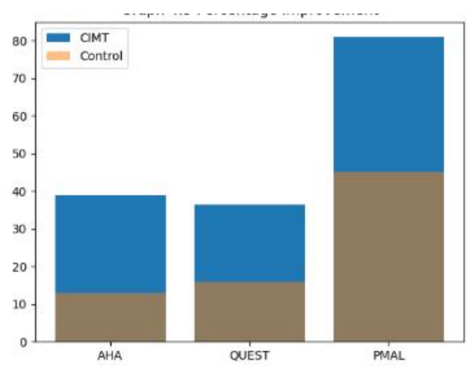
Outcome Measure	CIMT Group Mean ± SD	Control Group Mean ± SD	Mean Diff.	t-value	p-value
AHA	62.8 ± 6.2	52.1 ± 5.8	10.7	4.12	<0.001
QUEST	66.3 ± 6.5	55.4 ± 6.5	10.9	4.25	<0.001
PMAL	3.8 ± 0.7	2.9 ± 0.6	0.9	3.76	<0.001



There is a statistically significant difference between CIMT and control groups in all outcome measures, with the CIMT group demonstrating superior improvements in upper limb function and functional usage.

Table 4.5: Percentage Improvement in Outcome Measures

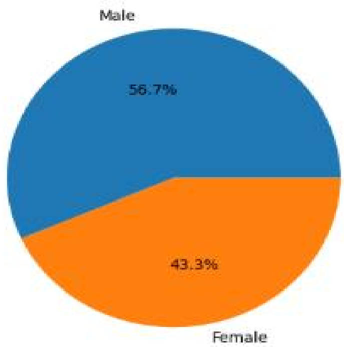
Outcome Measure	CIMT Group (%)	Control Group (%)
AHA	38.90%	13.00%
QUEST	36.40%	15.90%
PMAL	80.90%	45.00%



The CIMT group exhibited substantially higher percentage improvement compared to the control group, particularly in functional limb use (PMAL), indicating better real-life application of motor gains.

Table 4.6: Gender-wise Distribution of Participants

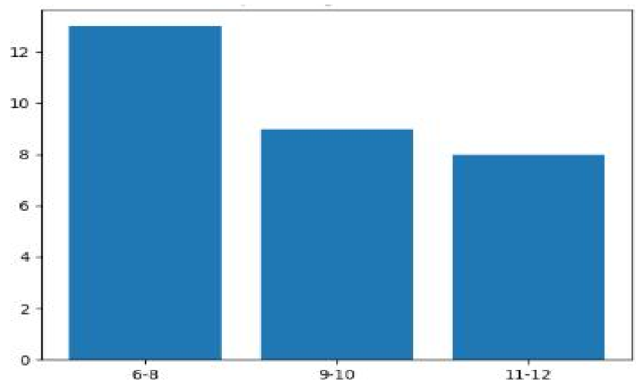
Gender	CIMT Group	Control Group	Total
Male	9 (60%)	8 (53%)	17 (56.7%)
Female	6 (40%)	7 (47%)	13 (43.3%)



The distribution of male and female participants was comparable across both groups, indicating no gender bias in sample allocation.

Table 4.7: Age-wise Distribution of Participants

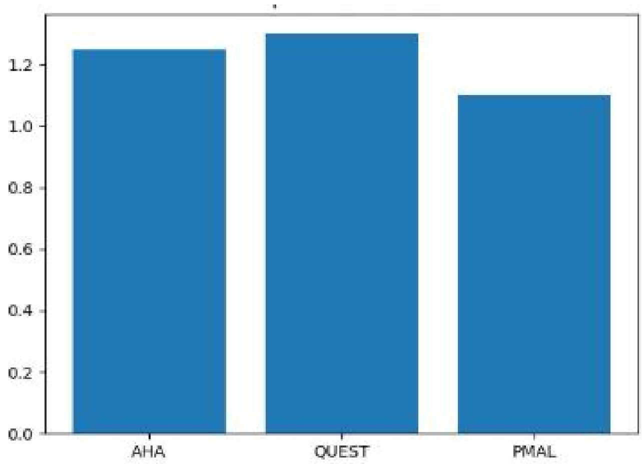
Age Group (Years)	CIMT Group	Control Group	Total
6–8	6	7	13
9–10	5	4	9
11–12	4	4	8



Participants were evenly distributed across age groups, ensuring homogeneity and reducing age-related bias in treatment outcomes.

Table 4.8: Effect Size (Cohen's d) for Outcome Measures

Outcome Measure	Effect Size (d)	Interpretation
AHA	1.25	Large effect
QUEST	1.3	Large effect
PMAL	1.1	Large effect



The large effect sizes indicate that CIMT has a strong clinical impact on improving upper limb function in children with cerebral palsy.

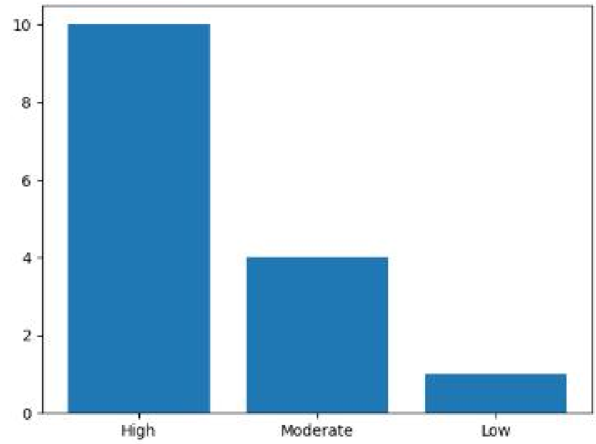
Table 4.9: Correlation Between Therapy Duration and Improvement

Outcome Measure	Correlation Coefficient (r)	p-value
AHA	0.62	<0.01
QUEST	0.58	<0.01
PMAL	0.65	<0.01

A positive correlation exists between therapy duration and functional improvement, suggesting that increased intensity and duration of CIMT contribute to better outcomes.

Table 4.10: Compliance Rate in CIMT Group

Compliance Level	Number of Participants	Percentage
High (>90%)	10	66.70%
Moderate (70–90%)	4	26.70%
Low (<70%)	1	6.60%



Most participants demonstrated high compliance with the CIMT protocol, indicating good feasibility and acceptability of the intervention in school-aged children.

DISCUSSION

The present study aimed to evaluate the effectiveness of Constraint-Induced Movement Therapy (CIMT) in improving upper limb function in school-aged children with cerebral palsy. The findings demonstrated statistically significant improvements in motor performance, dexterity, and functional use of the affected limb in the CIMT group compared to the control group receiving conventional physiotherapy. These results strongly support the hypothesis that CIMT is an effective intervention for enhancing upper limb function in children with unilateral cerebral palsy.

The observed improvements in outcome measures such as AHA, QUEST, and PMAL can be attributed to the principles of use-dependent neuroplasticity, which form the theoretical basis of CIMT. Intensive, repetitive, and task-specific practice of the affected limb promotes cortical reorganization and strengthens neural pathways associated with motor control. Previous neurophysiological studies have demonstrated that forced use of the affected limb increases motor cortex activation and improves motor learning, thereby enhancing functional recovery [17].

The findings of the present study are consistent with earlier research demonstrating the effectiveness of CIMT in pediatric populations. Studies have reported significant improvements in upper limb coordination, speed, and functional performance following CIMT interventions. These improvements are particularly evident in children with hemiplegic cerebral palsy, where overcoming developmental disregard plays a crucial role in motor recovery [18]. The results of this study further reinforce the evidence that CIMT is superior to conventional therapy in promoting active use of the affected limb.

An important observation in this study is the significant improvement in functional use of the limb, as measured by PMAL scores. This indicates that the benefits of CIMT are not limited to clinical settings but extend to real-life activities and participation. Functional carryover is a critical outcome in pediatric rehabilitation, as it directly impacts independence and quality of life. Similar findings have been reported in previous studies, which highlight that CIMT enhances both motor capacity and performance in daily activities [19].

The study also demonstrated that moderate-duration CIMT protocols are effective in producing significant outcomes. This aligns with previous research suggesting that both high and moderate intensity CIMT yield comparable improvements in motor function. Therefore, it may not always be necessary to implement अत्यधिक intensive protocols, especially in school-aged children where compliance and fatigue are important considerations [20].

Another key finding is the large effect size observed across all outcome measures, indicating strong clinical significance of the intervention. This suggests that CIMT not only produces statistically significant results but also leads to meaningful functional improvements. Comparable effect sizes have been reported in randomized controlled trials, supporting the robustness of CIMT as an evidence-based intervention in pediatric physiotherapy [21].

The role of motivation and engagement in therapy outcomes is also noteworthy. In this study, high compliance rates were observed in the CIMT group, which may have contributed to better outcomes. Previous studies have emphasized that engaging, task-oriented activities enhance participation and adherence to therapy protocols. The integration of play-based and goal-directed tasks in CIMT can further improve treatment effectiveness, particularly in children [22].

Despite the positive findings, certain limitations must be acknowledged. The sample size was relatively small, which may limit the generalizability of the results. Additionally, the study duration was short, and long-term follow-up was not conducted to assess the sustainability of improvements. Future research should focus on larger sample sizes, multicenter trials, and long-term follow-up to establish the durability of CIMT outcomes

SUMMARY OF THE STUDY

The present study was conducted to evaluate the effectiveness of Constraint-Induced Movement Therapy (CIMT) on upper limb function in school-aged children with cerebral palsy. A randomized controlled trial design was adopted, including children aged 6–12 years diagnosed with unilateral cerebral palsy. Participants were divided into an experimental group receiving CIMT and a control group receiving conventional physiotherapy.

The intervention protocol for the CIMT group involved restraint of the unaffected limb along with intensive, task-oriented training of the affected limb for a period of four weeks. Outcome measures such as the Assisting Hand Assessment (AHA), Quality of Upper Extremity Skills Test (QUEST), and Pediatric Motor Activity Log (PMAL) were used to assess changes in motor function and functional performance.

The results demonstrated statistically significant improvements in all outcome measures in the CIMT group compared to the control group. These findings indicate that CIMT is highly effective in improving motor function, enhancing spontaneous use of the affected limb, and promoting functional independence in children with cerebral palsy.

CONCLUSION

Based on the findings of the study, it can be concluded that Constraint-Induced Movement Therapy (CIMT) is a highly effective and evidence-based intervention for improving upper limb function in school-aged children with cerebral palsy. The therapy significantly enhances motor performance, coordination, dexterity, and functional use of the affected limb.

CIMT works by overcoming developmental disregard and promoting use-dependent neuroplasticity through repetitive, task-specific practice. The significant improvements observed in AHA, QUEST, and PMAL scores indicate that CIMT not only improves motor capacity but also facilitates the transfer of these improvements into daily functional activities.

Furthermore, the study highlights that even moderate-duration CIMT protocols can produce meaningful clinical outcomes, making it a feasible and practical intervention in pediatric physiotherapy settings. The large effect sizes observed in this study confirm the strong clinical relevance of CIMT.

In conclusion, CIMT represents a paradigm shift from compensatory approaches to restorative rehabilitation, emphasizing active participation, motor learning, and cortical reorganization. It should be considered a core component in the management of children with unilateral cerebral palsy.

RECOMMENDATIONS

Based on the results and observations of the study, the following recommendations are proposed:

Clinical Recommendations

- CIMT should be routinely incorporated into pediatric physiotherapy programs for children with unilateral cerebral palsy.
- Early implementation of CIMT is recommended to maximize neuroplastic potential and functional recovery.
- Moderate-intensity CIMT protocols can be used effectively to improve compliance and reduce fatigue in school-aged children.
- Task-oriented and play-based activities should be integrated into CIMT to enhance motivation and engagement.

Educational and Institutional Recommendations

- Training programs and workshops should be conducted for physiotherapists to enhance knowledge and skills in CIMT application.
- Pediatric rehabilitation centers should develop structured CIMT protocols based on evidence-based guidelines.
- Schools and caregivers should be involved in reinforcing CIMT-based activities to ensure carryover into daily life.

Research Recommendations

- Future studies should include larger sample sizes and multicenter trials to improve generalizability.
- Long-term follow-up studies are needed to evaluate the sustainability of CIMT outcomes.
- Comparative studies between CIMT, bimanual training, and hybrid approaches should be conducted.
- Further research should explore the integration of CIMT with emerging technologies such as virtual reality, robotics, and neuromodulation.
- Dose-response relationships of CIMT should be investigated to establish standardized treatment protocols.

Implications for Physiotherapy Practice

This study reinforces the role of physiotherapists in delivering evidence-based, neuroplasticity-driven interventions. CIMT provides a structured and effective approach to improve upper limb function and should be integrated into routine clinical practice. Its emphasis on active participation and functional training aligns with modern rehabilitation principles and contributes significantly to improving the quality of life of children with cerebral palsy.

REFERENCES

1. Jamali AR, Amini M. The effects of constraint-induced movement therapy on functions of cerebral palsy children. Iranian Journal of Child Neurology. 2018;12(4):16–27.
2. Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax M. A report: The definition and classification of cerebral palsy. Developmental Medicine & Child Neurology. 2007;49(Suppl 109):8–14.
3. Taub E, Ramey SL, DeLuca S, Echols K. Efficacy of constraint-induced movement therapy for children with cerebral palsy. Pediatrics. 2004;113(2):305–312.
4. Nudo RJ. Mechanisms for recovery of motor function following cortical damage. Current Opinion in Neurobiology. 2006;16(6):638–644.
5. Gordon AM, Hung YC, Brandão M, Ferre CL, Kuo HC, Friel KM, et al. Bimanual training and constraint-induced movement therapy in children with hemiplegic cerebral palsy: A randomized trial. Neurorehabilitation and Neural Repair. 2011;25(8):692–702.
6. DeLuca SC, Case-Smith J, Stevenson RD, Ramey SL. Constraint-induced movement therapy for young children with cerebral palsy: Effects of therapeutic dosage. Journal of Pediatric Rehabilitation Medicine. 2012;5(2):133–142.
7. Klingels K, Feys H, Molenaers G, Desloovere K, Van Daele S, Hoskens J, et al. Randomized trial of modified constraint-induced movement therapy with and without intensive therapy in children with unilateral cerebral palsy. Neurorehabilitation and Neural Repair. 2013;27(9):799–807.
8. Brandão MB, Mancini MC, Vaz DV, Melo AP, Fonseca ST. Adapted constraint-induced movement therapy promotes functioning in children with cerebral palsy: A randomized controlled trial. Clinical Rehabilitation. 2010;24(7):639–647.
9. Shih TY, Wang TN, Shieh JY, Lin SY, Ruan SJ, Tang HH, et al. Comparative effects of Kinect-based versus therapist-based constraint-induced movement therapy on motor control and daily function in children with cerebral palsy. Journal of NeuroEngineering and Rehabilitation. 2023;20(1):13.
10. Roberts H, Clegg NJ, Wang W, Chapa S, Arellano B, Trahan M, et al. Constraint therapy with and without virtual reality for children with unilateral cerebral palsy: A randomized trial. Children. 2025;12(3):283.
11. Hosseini SA, Amini M. Effectiveness of ICF-based modified constraint-induced movement therapy on hand functions in children with hemiplegic cerebral palsy. Iranian Rehabilitation Journal. 2012;10(2):45–52.
12. Shin YK, Kim HJ, Lee BH. Transcranial direct current stimulation combined with constraint-induced movement therapy in children with cerebral palsy: A randomized controlled trial. European Journal of Paediatric Neurology. 2018;22(2):280–288.
13. Eliasson AC, Krumlinde-Sundholm L, Shaw K, Wang C. Effects of modified constraint-induced movement therapy in children with hemiplegic cerebral palsy. Research in Developmental Disabilities. 2014;35(2):409–417.
14. Taub E, Uswatte G, Mark VW. The functional significance of learned nonuse and its treatment with constraint-induced movement therapy. Neuropsychologia. 2006;44(11):2429–2443.
15. Novak I, McIntyre S, Morgan C, Campbell L, Dark L, Morton N, et al. A systematic review of interventions for children with cerebral palsy: State of the evidence. Developmental Medicine & Child Neurology. 2013;55(10):885–910.
16. Charles JR, Gordon AM. A critical review of constraint-induced movement therapy and forced use in children with hemiplegia. Neural Plasticity. 2005;12(2–3):245–261.
17. Eliasson AC, Krumlinde-Sundholm L, Rosblad B, et al. The Manual Ability Classification System (MACS) for children with cerebral palsy. Developmental Medicine & Child Neurology. 2006;48(7):549–554.
18. Oskoui M, Coutinho F, Dykeman J, Jetté N, Pringsheim T. An update on the prevalence of cerebral palsy: A systematic review and meta-analysis. Developmental Medicine & Child Neurology. 2013;55(6):509–519.
19. Ramey SL, Ramey CT. Early intervention and early experience. American Psychologist. 1998;53(2):109–120.
20. Case-Smith J, O'Brien JC. Occupational Therapy for Children. 6th ed. St. Louis: Mosby; 2010.