

Dose Characteristics of Constraint-Induced Movement Therapy for Fine Motor Function in Children with Cerebral Palsy

Noor Shinta Devi¹

¹Universitas Muhammadiyah Surakarta, Indonesia

Corresponding author:

Name: Noor Shinta Devi

E-mail: Nshintadevi1@gmail.com

Phone: 082254103990

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Abstract

Background: Constraint-induced movement therapy (CIMT) is used to improve upper limb function in children with cerebral palsy (CP), but treatment protocols vary substantially in duration, frequency, intensity, and type of constraint.

Objective: To synthesize evidence on CIMT dose characteristics and fine motor outcomes in children with CP.

Methods: A systematic review was conducted using PubMed, ScienceDirect, and Google Scholar. Randomized controlled trials, systematic reviews, and meta-analyses published between 2016 and 2026 were eligible. Six primary studies and two secondary evidence syntheses were included. Fine motor outcomes included grasping, visual motor integration, manual dexterity, and hand function. Evidence was synthesized narratively because of substantial heterogeneity.

Results: CIMT protocols ranged from 30 minutes to 6 hours daily, 3 to 6 sessions weekly, and 2 to 12 weeks. Some studies reported greater improvement with higher intensity, whereas others reported more favorable outcomes with lower daily duration distributed over longer periods. Comparative findings were inconsistent. Secondary evidence suggested potential benefits for upper limb function but did not establish total dose as a consistent determinant of treatment effect.

Conclusion: CIMT may improve selected fine motor and hand function outcomes in children with CP. However, heterogeneity in intervention protocols, comparators, outcome measures, and study quality prevents identification of an optimal dose. Further standardized trials are needed.

Keywords

Cerebral Palsy; Constraint-Induced Movement Therapy; Fine Motor Skills; Upper Extremity; Rehabilitation

Introduction

Cerebral palsy (CP) comprises a group of permanent disorders of movement and posture resulting from a nonprogressive disturbance in the developing fetal or infant brain. The condition can affect motor control, functional performance, and participation in daily activities, with the nature and severity of impairment varying according to motor subtype and the distribution of involvement.^{1,2} As one of the major causes of childhood physical disability, CP often requires long-term rehabilitation aimed at improving functional independence and participation.³

Upper limb impairment is particularly relevant in children with unilateral or asymmetric CP because impaired motor control can affect reaching, grasping, object manipulation, and coordinated hand use.⁴ These limitations may interfere with the acquisition and performance of age-appropriate functional activities.⁴ Consequently, rehabilitation interventions increasingly emphasize active, repetitive, task-oriented, and goal-directed practice to improve motor performance and functional use of the more affected upper limb.^{5,6}

Constraint-induced movement therapy (CIMT) is an intervention designed to increase the use of the more affected upper limb by restricting the less affected limb while providing intensive and structured practice.⁴ Modified constraint-induced movement therapy (mCIMT) applies the same general therapeutic principle but uses protocols adapted to the child's age, tolerance, clinical characteristics, and rehabilitation context.⁷ However, CIMT and mCIMT protocols vary considerably across studies in daily training duration, session frequency, overall program length, cumulative treatment exposure, distribution of practice, and the type of constraint used.^{4,6} This variation is clinically important because treatment response may depend not only on the total amount of practice but also on how the intervention is distributed and delivered.⁸

Previous evidence suggests that CIMT may improve selected upper limb outcomes in children with CP, although the consistency and certainty of these findings remain limited.⁴ A systematic review and meta-analysis by Baker et al. reported that CIMT may improve function of the more affected hand in infants and toddlers with CP compared with bimanual play or massage; however, the certainty of evidence was very low.⁹ More recently, Wang et al.⁷ reported a positive overall effect of mCIMT on upper limb function, with a Hedges' *g* of 0.58 and a 95% confidence interval of 0.02 to 1.14.⁷ Nevertheless, the certainty of the available evidence remained limited, and the findings did not establish a definitive optimal treatment dose.⁷

The available evidence also indicates that treatment dose should not be interpreted solely as the number of training hours.⁴ CIMT protocols differ not only in cumulative exposure but also in daily duration, frequency, total program length, temporal distribution of practice, and type of constraint.^{4,7} These components may interact with participant characteristics, adherence, treatment tolerance, co-interventions, and the outcome being assessed.¹⁰ Therefore, a protocol with a greater daily training duration cannot automatically be assumed to produce superior outcomes compared with a lower daily duration delivered over a longer period.¹¹

Another challenge concerns the heterogeneity of outcome terminology used in CIMT research.⁴ Studies have assessed grasping, visual motor integration, manual dexterity, hand function, reaching, grip strength, bimanual performance, and broader upper limb function. Although these domains are related, they are not interchangeable. In the present review, fine motor function refers primarily to outcomes involving hand use, object manipulation, grasping, manual dexterity, visual motor integration, or standardized

hand function performance. Broader measures, including reaching, grip strength, head control, eating, bimanual performance, and general upper limb function, are considered contextual outcomes rather than direct indicators of fine motor function. This distinction is necessary to prevent conclusions regarding fine motor ability from extending beyond the outcomes directly assessed in the available studies.

Important uncertainty also remains regarding the relationship between CIMT dose characteristics and treatment outcomes.⁴ The review by Baker et al. primarily examined motor interventions in infants and toddlers and did not specifically focus on the multidimensional characteristics of CIMT dosing.⁹ Similarly, the more recent meta-analysis by Wang et al. evaluated the overall effectiveness of mCIMT for upper limb function but did not establish a single optimal dose.⁷ Evidence comparing CIMT with bimanual training has also focused primarily on comparative effectiveness rather than providing an integrated analysis of how specific components of treatment delivery may contribute to differences in fine motor outcomes.¹²

This gap is clinically relevant because CIMT is often implemented using markedly different schedules and intensities.⁴ Some protocols involve relatively short daily sessions over several weeks, whereas others use intensive daily practice delivered over shorter intervention periods. The available primary studies also report different types of constraints, including casts, splints, gloves, and slings.^{12,13} These variations make it difficult to determine whether differences in treatment outcomes are attributable to total exposure, daily intensity, frequency, distribution of practice, the type of constraint, comparator characteristics, or the interaction among these factors.

Accordingly, the present systematic review aimed to synthesize available evidence on the dose characteristics of CIMT and mCIMT in relation to fine motor outcomes in children with CP. The review specifically examined daily or session duration, frequency, overall program length, estimated cumulative exposure, distribution of practice, and type of constraint. Primary intervention studies were considered separately from systematic reviews and meta-analyses to avoid overlap and double counting. By distinguishing direct fine motor outcomes from broader contextual upper limb outcomes and interpreting dose as a multidimensional construct, this review aimed to clarify current evidence regarding the relationship between CIMT dose characteristics and treatment outcomes. The findings were also intended to determine whether the available evidence is sufficient to support conclusions regarding an optimal CIMT or mCIMT dose for improving fine motor function in children with CP.

Methods

This systematic review was conducted to synthesize evidence on the dose characteristics of constraint-induced movement therapy (CIMT) and modified constraint-induced movement therapy (mCIMT) in relation to fine motor outcomes in children with cerebral palsy (CP). The review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 statement.¹⁴ The review protocol was not prospectively registered; therefore, no registration number is available. The eligibility criteria and analytical framework were established according to the review objective before the final synthesis.

Study eligibility was defined using the Population, Intervention, Comparison, Outcome, and Study Design framework. The population included children with CP, primarily aged 2 to 10 years. The intervention consisted of CIMT or mCIMT involving restriction of the less affected upper limb combined with structured training of the more affected upper limb. Comparators included alternative CIMT protocols, conventional therapy, mirror visual feedback, static weight bearing, bimanual training, or other relevant rehabilitation interventions. The primary outcome was fine motor function, operationally defined as grasping, object manipulation, manual dexterity, visual motor integration, or standardized hand function performance. Reaching, grip strength, head control, eating, bimanual performance, and broader upper limb function were classified as secondary or contextual outcomes and were not interpreted as direct measures of fine motor function.

Randomized controlled trials, systematic reviews, and meta-analyses published between 2016 and 2026 were eligible for inclusion. Studies were excluded if they did not investigate CIMT or mCIMT, involved populations not relevant to the review question, did not report outcomes related to hand or upper limb motor performance, were published outside the predefined period, or lacked accessible full text. Primary intervention studies and secondary evidence syntheses were analyzed separately to reduce the risk of overlap and double counting.

The literature search was conducted in PubMed, ScienceDirect, and Google Scholar during July 2026. Search concepts combined terms related to CIMT, CP, and motor or hand function. In PubMed, the search included the following combinations: “((Constraint Induced Movement Therapy) AND (Motoric)) AND (Cerebral Palsy)” and “((((CONSTRAINT INDUCED MOVEMENT THERAPY) OR (CIMT)) AND (Motoric)) OR (Motor Skill)) AND (Cerebral Palsy) OR (CP).” In ScienceDirect, the search used “Constraint Induced Movement Therapy” “Motoric” “Cerebral palsy” and “(Constraint Induced Movement Therapy) OR “CIMT”) (“Motoric” OR “Motor Skill”) (“Cerebral palsy” OR “CP”). In Google Scholar, the advanced search included the terms “Constraint Induce Movement Therapy,” “CIMT,” “Motoric,” “Motor Skill,” “Cerebral Palsy,” and “CP.” Filters included publication years 2016 to 2026, English-language articles, randomized controlled trials, systematic reviews, and meta-analyses where available. Free full text was applied in PubMed, whereas open access and open archive criteria were applied in ScienceDirect. In Google Scholar, eligibility of freely accessible full texts was assessed manually.

The original search records did not preserve the number of records retrieved from each individual database before and after filtering. Therefore, database-specific retrieval counts could not be reported. The documented screening flow indicated that 2,317 records were initially identified and 428 records remained after predefined filters were applied. Records were screened by title and abstract, resulting in 36 full-text articles being assessed for eligibility. Duplicate records were identified manually by examining identical or substantially matching titles and were marked during screening; however, the number of duplicates removed was not recorded. Twenty-eight full-text articles were excluded because they did not meet the eligibility criteria, but specific study-level reasons for exclusion were not preserved. Consequently, individual exclusion reasons were not reconstructed retrospectively.

Study selection and data extraction were performed by one reviewer. Independent duplicate screening or extraction by a second reviewer was not documented. This approach may have increased the risk of selection and extraction bias and was considered when interpreting the findings. Data were extracted into a predefined table containing study design, participant characteristics, intervention and comparator, daily or session duration, frequency, program length, estimated cumulative exposure when calculable, distribution of practice, type of constraint, outcome measures, main findings, effect estimates, confidence intervals, P values, and follow-up information when available.

Methodological quality of the six primary studies was assessed using the Physiotherapy Evidence Database (PEDro) scale, while the two secondary evidence syntheses were assessed using the Joanna Briggs Institute (JBI) critical appraisal checklist. The reported PEDro scores ranged from 5/10 to 7/10. Two studies received scores of 5/10, two received scores of 6/10, and two received scores of 7/10. Both secondary evidence syntheses satisfied all 11 JBI checklist items. The appraisal findings were considered when

interpreting the consistency and certainty of the evidence. Studies with methodological limitations or indirect outcome measures were interpreted cautiously and were not considered equivalent to evidence directly evaluating fine motor function.

Because of substantial heterogeneity in intervention protocols, participant characteristics, comparators, outcome measures, and reporting of quantitative effects, no meta-analysis was performed. A narrative synthesis was conducted by first separating primary studies from secondary evidence syntheses. The primary studies were then compared according to daily or session duration, frequency, overall program length, estimated cumulative treatment exposure, distribution of practice, and type of constraint. Outcomes were grouped into direct fine motor or hand function outcomes and broader contextual upper limb outcomes. The synthesis distinguished within-group improvement from comparative superiority and considered methodological quality, effect estimates, statistical significance, confidence intervals, and follow-up findings when reported.

The study selection process is presented in a PRISMA 2020 flow diagram. The documented screening process included 2,317 records identified through database searching, 428 records remaining after predefined filters, 36 reports assessed in full text, 28 reports excluded because they did not meet the eligibility criteria, and eight studies included in the final synthesis. The final evidence comprised six primary intervention studies and two systematic reviews or meta-analyses used as contextual secondary evidence. Because database-specific retrieval counts, the exact number of duplicates, and individual full-text exclusion reasons were not preserved, these limitations are explicitly acknowledged and should be considered when interpreting the transparency and reproducibility of the review.

Results

The study selection process is summarized in Figure 1. A total of 2,317 records were identified through database searching. After predefined filters were applied, 428 records remained for title and abstract screening. Of these, 392 records were excluded, and 36 reports were sought for retrieval and assessed for full-text eligibility. All 36 reports were available for assessment, whereas 28 reports were excluded because they did not meet the eligibility criteria. The specific reasons for exclusion and the exact number of duplicate records removed were not preserved in the original review records and were therefore not reconstructed retrospectively. Ultimately, eight studies were included in the qualitative synthesis, comprising six primary intervention studies and two systematic reviews or meta-analyses. No quantitative meta-analysis was performed because of substantial heterogeneity in intervention protocols, comparators, outcome measures, and study designs.

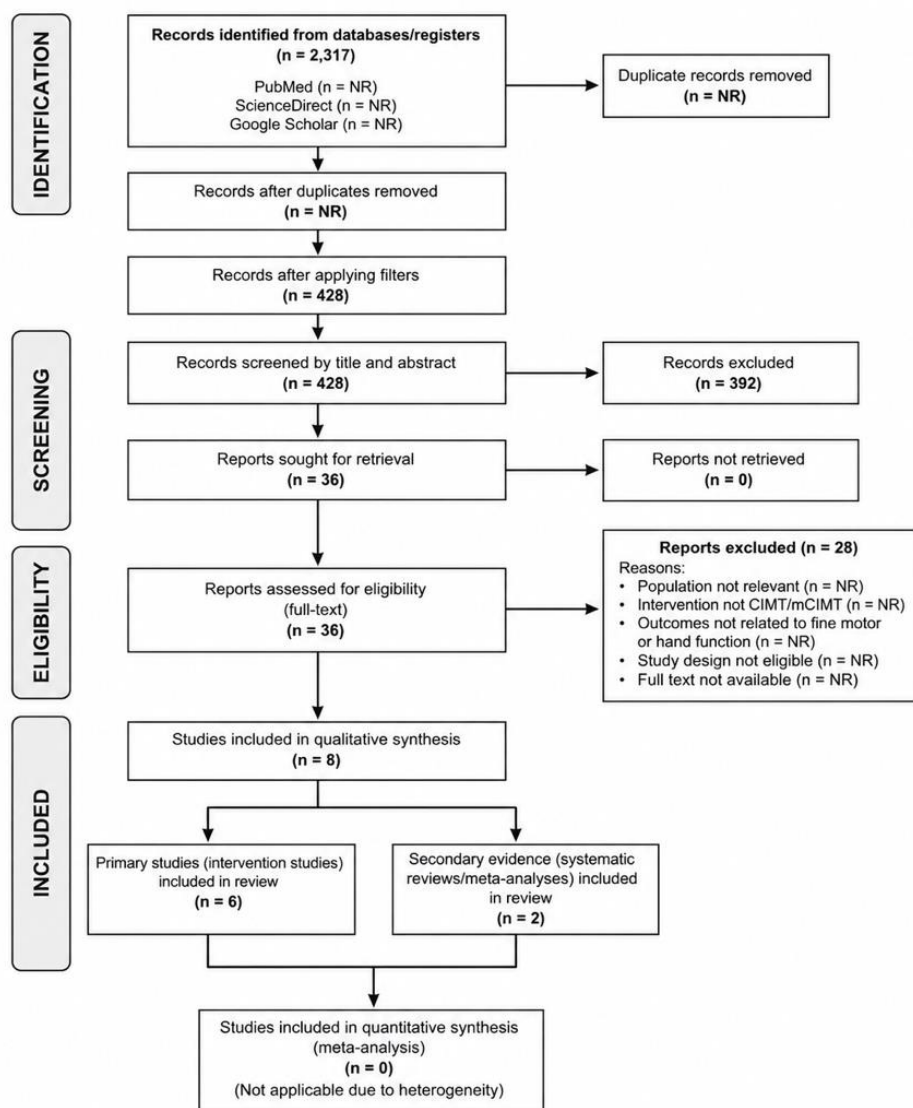


Figure 1. PRISMA 2020 flow diagram of the study selection process.

The study selection process resulted in a final body of evidence with considerable clinical and methodological diversity. The six primary studies were analyzed separately from the two secondary evidence syntheses to avoid overlap and double counting. Across the primary studies, CIMT and mCIMT protocols varied from 30 minutes to 6 hours per day, with intervention frequencies

ranging from 3 to 6 days per week and program durations ranging from 2 to 12 weeks.¹⁵ The temporal distribution of treatment also differed substantially, with some studies applying intensive daily practice over a short period and others distributing shorter sessions over several weeks. Different forms of constraint, including casts, splints, gloves, and slings, were also used.

To facilitate comparison of these multidimensional dose characteristics and their relationship with outcomes, Table 2 summarizes the intervention protocols, comparators, outcome domains, and principal findings of the six primary studies. Fine motor outcomes were distinguished from broader upper limb outcomes wherever possible.

Table 2. Characteristics and Findings of Primary Studies

Study	Intervention and Dose Characteristics	Constraint	Comparator	Main Outcome	Main Findings and Available Quantitative Results
Ramey et al., 2021	High dose: 3 h/session; low dose: 2.5 h/session; 3 days/week for 4 weeks	Cast or splint	Alternative CIMT dose and constraint	Assisting Hand Assessment; PDMS-2 visual motor integration	The high-dose protocol demonstrated more favorable outcomes. The greatest improvement in Assisting Hand Assessment was observed in the high-dose cast group, while PDMS-2 visual motor integration also showed greater improvement with the high-dose treatment condition.
Wu et al., 2020	Protocol 1: 4 h/day for 2 weeks; Protocol 2: 2 h/day for 4 weeks	Not specified in available data	Different CIMT dose distribution	Grasping; visual motor integration	Both protocols were associated with improvement. The 2 h/day for 4 weeks protocol showed more favorable findings. Significant changes were reported, with $P < 0.001$ and $P = 0.001$. Improvements were maintained at the 4-week follow-up, with $P < 0.001$ and $P = 0.012$.
Hung et al., 2020	6 h/day for 15 consecutive working days	Cotton sling	Hand Arm Bimanual Intensive Therapy	Grasping and contextual upper limb outcomes	Both groups improved. The CIMT group demonstrated a significant change in grasping-related performance, $F(1,18) = 4.47$, $P = 0.049$, $\eta^2 = 0.28$. Reaching and head control were interpreted as broader upper limb outcomes.
Abdel Ghafar et al., 2025	mCIMT: 30 min/session, 5 times/week for 12 weeks	Not specified in available data	Mirror visual feedback	Manual dexterity	Both groups improved, but mCIMT demonstrated a greater mean improvement of 6.33 blocks on the Box and Block Test, 95% CI 3.593 to 9.066, $P = 0.001$. The within-group effect size was 1.26, while the post-intervention comparison favored mCIMT, $P = 0.014$, Cohen's $d = 0.75$.
Narayan et al., 2025	45 min/day divided into 3 sessions, 6 days/week for 2 weeks	Glove	Static weight bearing	Grasping; visual motor integration	Both groups improved, but static weight bearing demonstrated greater improvement. CIMT improved grasping by 12.78% and visual motor integration by 4.88%, whereas static weight bearing improved grasping by 37.67% and visual motor integration by 14.11%.
Ilyas, 2025	mCIMT: 6 h/day, 5 days/week for 3 weeks, plus 1 h/day conventional physiotherapy	Not specified in available data	Bimanual training	Jebsen Taylor Test of Hand Function	Both groups improved after treatment and at follow-up. mCIMT demonstrated more favorable hand function outcomes, with Cohen's $d = 1.13$ after intervention and $d = 1.61$ at the 6-month follow-up.

Abbreviations: CIMT, constraint-induced movement therapy; mCIMT, modified constraint-induced movement therapy; PDMS-2, Peabody Developmental Motor Scales, Second Edition; CI, confidence interval.

As shown in Table 2, the relationship between treatment intensity and outcome was not consistent across studies. Ramey et al.¹³ reported more favorable outcomes with the higher-dose protocol, suggesting that increased treatment exposure may benefit selected measures of hand use and visual motor integration.¹³ In contrast, Wu et al.¹⁶ found more favorable outcomes when a lower daily treatment duration was distributed over a longer intervention period.¹⁶ These findings indicate that daily duration alone is insufficient to explain treatment response and that the temporal distribution of practice may also influence outcomes.

The remaining studies further demonstrated the complexity of the relationship between CIMT dose and clinical outcomes. Hung et al. reported significant improvement in grasping-related performance following an intensive 6-hour daily protocol, whereas Abdel Ghafar et al. observed clinically favorable outcomes with a substantially lower daily duration delivered over 12 weeks. Conversely, Narayan et al.¹⁷ found that static weight bearing produced greater improvement than CIMT for grasping and visual motor integration.¹⁷ Ilyas reported favorable outcomes for mCIMT compared with bimanual training, with large effect sizes maintained at follow-up.¹⁸ Collectively, these findings indicate that improvements within CIMT groups do not consistently translate into superiority over alternative interventions.

The two secondary evidence syntheses were evaluated separately to provide broader context regarding the effectiveness and dose characteristics of CIMT and mCIMT. Because these studies included primary trials that may overlap conceptually with the evidence considered in the present review, they were not combined quantitatively with the six primary studies. Their characteristics and principal findings are summarized in Table 3.

Table 3. Characteristics and Findings of Secondary Evidence Syntheses

Study	Evidence Base	CIMT Characteristics	Dose	Outcome	Main Findings
Baker et al., 2022	4 RCTs; total $n = 150$	28 days to 12 weeks; 1 to 6 sessions/week; 30 min to 6 h/day		Unilateral hand and upper limb function	CIMT showed $SMD = 0.59$, 95% CI -0.18 to 1.37 , $P = 0.13$. Fine motor function was not analyzed as an independent primary outcome.
Wang et al., 2025	10 RCTs; 54 effect sizes	3 to 10 weeks; 3 to 7 sessions/week; 1 to 3 h/day		Upper limb function	mCIMT demonstrated a significant overall effect, Hedges' $g = 0.58$, 95% CI 0.02 to 1.14 , $P = 0.043$. Studies with a total dose below 30 h showed significant improvement, but total dose was not identified as a statistically significant moderator of treatment effect.

Abbreviations: CIMT, constraint-induced movement therapy; mCIMT, modified constraint-induced movement therapy; RCT, randomized controlled trial; SMD, standardized mean difference; CI, confidence interval.

As summarized in Table 3, the secondary evidence supports the potential benefit of CIMT and mCIMT for selected hand and upper limb outcomes but does not establish a definitive optimal dose. Baker et al.⁹ reported a moderate but statistically non-significant effect, whereas Wang et al.⁷ demonstrated a statistically significant overall effect of mCIMT on upper limb function.^{7,9} However, neither synthesis consistently evaluated fine motor function as an independent outcome, limiting the extent to which their findings can directly inform dose recommendations specifically for fine motor performance.

Overall, the included evidence demonstrated substantial variation in daily treatment duration, frequency, total program length, temporal distribution of practice, cumulative exposure, and type of constraint. Higher daily intensity was associated with more favorable outcomes in some studies, whereas lower daily duration distributed over a longer intervention period was associated with better outcomes in others. Alternative interventions also produced comparable or superior improvements in selected outcomes. Therefore, the available evidence suggests that CIMT and mCIMT may improve selected fine motor and hand function outcomes in children with CP, but the current evidence does not demonstrate a consistent dose-response relationship or provide a sufficient basis for identifying a single optimal CIMT or mCIMT dose.

Discussion

This systematic review synthesized evidence regarding the dose characteristics of constraint-induced movement therapy (CIMT) and modified constraint-induced movement therapy (mCIMT) in relation to fine motor outcomes in children with cerebral palsy (CP). The principal finding was that CIMT and mCIMT were associated with improvements in selected fine motor and hand function outcomes across several studies; however, the available evidence did not demonstrate a consistent dose-response relationship. Differences in daily treatment duration, frequency, program length, temporal distribution of practice, cumulative exposure, type of constraint, comparator intervention, and outcome measurement made direct comparisons difficult. Consequently, the current evidence does not support the identification of a single optimal CIMT or mCIMT dose.

One important finding was that greater daily treatment duration was not consistently associated with superior outcomes. Ramey et al.¹³ reported more favorable outcomes with the higher-dose protocol, suggesting that increased treatment exposure may benefit selected aspects of hand use and visual motor integration.¹³ In contrast, Wu et al. reported more favorable findings with a lower daily duration delivered over a longer intervention period.¹⁶ This contrast suggests that treatment dose should not be interpreted as a single quantitative variable. The temporal distribution of practice may influence opportunities for repetition, skill consolidation, adaptation, and participation, while excessively concentrated practice may not necessarily provide additional benefit across all outcomes. However, these interpretations should remain cautious because the included studies differed in participant characteristics, intervention procedures, comparators, and outcome measures.

The findings also indicate that cumulative treatment exposure alone may be insufficient to explain variation in outcomes. Abdel Ghafar et al. reported favorable manual dexterity outcomes using a relatively short daily session delivered over 12 weeks, whereas Hung et al. observed improvement following an intensive protocol of 6 hours per day over 15 consecutive working days. Ilyas also reported favorable hand function outcomes following an intensive mCIMT protocol, although conventional physiotherapy was provided concurrently.¹⁸ These findings suggest that different combinations of treatment intensity and duration may produce beneficial outcomes, but they do not establish that one combination is superior across all children or all functional domains. The presence of co-interventions and differences in comparators further complicate interpretation of the independent effect of CIMT dose.

The type of constraint may represent another relevant component of treatment delivery.⁴ The included studies used casts, splints, gloves, and slings, which may differ in the extent to which they restrict the less affected upper limb and influence adherence or tolerance. The findings from Ramey et al. suggested differences associated with constraint conditions, while other studies provided insufficient information to isolate the contribution of the restraint itself. Therefore, the type of constraint should be considered part of the multidimensional treatment protocol rather than a minor procedural detail. Future studies should report the specific characteristics of the constraint, including duration of wear, degree of restriction, supervision, and adherence, to facilitate more meaningful comparisons.

Comparator selection also influenced the interpretation of treatment effectiveness. Some studies compared different CIMT doses, whereas others compared CIMT or mCIMT with mirror visual feedback, static weight bearing, bimanual training, or Hand Arm Bimanual Intensive Therapy. As a result, superiority of CIMT cannot be interpreted independently of the alternative intervention against which it was tested. Narayan et al.¹⁷, for example, reported greater improvement with static weight bearing for grasping and visual motor integration, whereas Ilyas reported more favorable outcomes with mCIMT than with bimanual training.^{17,18} These contrasting findings reinforce the importance of distinguishing within-group improvement from comparative superiority. CIMT may produce meaningful functional improvement without necessarily being consistently superior to other active rehabilitation approaches.

The secondary evidence provided additional context but did not resolve the uncertainty regarding optimal dose. Baker et al.⁹ reported a moderate but statistically non-significant effect for unilateral hand function, while Wang et al.⁷ reported a statistically significant overall effect of mCIMT on upper limb function.^{7,9} Importantly, Wang et al. found that total intervention dose was not a statistically significant moderator of treatment effect, despite significant improvement in some subgroup analyses involving lower cumulative doses.⁷ This finding is consistent with the pattern observed in the primary studies, in which greater exposure was not uniformly associated with greater benefit. Nevertheless, the secondary evidence should not be interpreted as direct confirmation of the present findings because fine motor function was not consistently analyzed as an independent outcome.

Outcome heterogeneity represents a major consideration in interpreting the evidence. Grasping, visual motor integration, manual dexterity, hand function, and bimanual performance reflect related but distinct aspects of upper limb performance. Similarly, broader measures such as reaching, grip strength, or head control should not automatically be considered equivalent to fine motor function. The present review therefore distinguished direct fine motor and hand outcomes from contextual upper limb outcomes. This distinction is particularly important when evaluating dose-response relationships because a protocol that improves one functional domain may not necessarily produce the same magnitude of benefit in another domain.

The findings have several clinical implications. Rather than prescribing a universal number of daily treatment hours, clinicians may need to consider CIMT dose as a combination of daily duration, frequency, total program length, distribution of practice, type of constraint, treatment goals, child tolerance, and the availability of alternative therapies. A lower daily duration delivered over a longer period may be appropriate for some children, whereas more intensive protocols may be feasible and beneficial in other contexts. However, the current evidence is insufficient to recommend one specific dose as optimal. Dose selection should therefore remain individualized and aligned with the functional outcome being targeted.

This review also highlights important methodological limitations in the available evidence. The included studies varied substantially in sample characteristics, intervention protocols, comparators, outcome measures, and follow-up periods. Several

studies assessed broader upper limb outcomes rather than fine motor function as a distinct primary domain. Co-interventions were also present in some protocols, limiting attribution of observed effects exclusively to CIMT or mCIMT. In addition, the methodological quality of the primary studies ranged from 5/10 to 7/10 on the PEDro scale, indicating variation in internal validity. The review process itself was limited by the use of a single reviewer, the absence of prospectively preserved duplicate-screening records, and incomplete documentation of database-specific retrieval counts and individual full-text exclusion reasons.

Overall, the evidence suggests that CIMT and mCIMT may improve selected fine motor and hand function outcomes in children with CP, but treatment response appears to depend on more than cumulative training time. The available findings support a multidimensional interpretation of dose in which intensity, frequency, program duration, temporal distribution, type of constraint, comparator, and outcome domain may all contribute to observed effects. Further well-designed randomized controlled trials using standardized reporting of dose components, adherence, constraint characteristics, and outcome-specific measures are required to determine whether particular combinations of CIMT parameters provide more consistent benefits for fine motor function.

Conclusion

Constraint-induced movement therapy (CIMT) and modified constraint-induced movement therapy (mCIMT) may improve selected fine motor and hand function outcomes in children with cerebral palsy (CP). However, the available evidence does not demonstrate a consistent relationship between greater treatment exposure and superior outcomes. Across the included studies, intervention protocols varied substantially in daily duration, frequency, total program length, temporal distribution of practice, cumulative exposure, and type of constraint. Higher daily intensity was associated with more favorable outcomes in some studies, whereas lower daily treatment duration distributed over a longer intervention period was associated with better outcomes in others.

The findings therefore indicate that CIMT dose should be considered a multidimensional construct rather than being defined solely by the number of treatment hours. Treatment response may be influenced by the interaction between intervention intensity, frequency, program duration, distribution of practice, type of constraint, comparator intervention, and the specific functional outcome assessed. Moreover, improvements observed within CIMT or mCIMT groups were not consistently accompanied by superiority over alternative rehabilitation interventions.

Overall, the current evidence supports the potential role of CIMT and mCIMT in improving selected fine motor and hand function outcomes, but it remains insufficient to identify a single optimal treatment dose. Future randomized controlled trials should use standardized reporting of dose characteristics, adherence, constraint procedures, co-interventions, and outcome-specific measures. Such studies are necessary to clarify whether particular combinations of CIMT parameters provide more consistent and clinically meaningful benefits for fine motor function in children with CP.

Author Contribution

Noor Shinta Devi: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing Original Draft, Writing Review and Editing, Visualization, Project Administration.

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Conflict of Interest Statement

The author declares no conflict of interest related to the preparation or publication of this study.

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Ethics Statement

This study was a systematic review based on previously published literature and did not involve direct recruitment of human participants, collection of identifiable personal data, or animal experimentation. Therefore, ethical approval and informed consent were not required.

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