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A Comparative Study on Effectiveness of Hand Arm Bimanual Intensive Therapy and Core Stability Exercise on Improving Upper Extremity Function Among Cerebral Palsy Children

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Abstract

Background: Cerebral palsy (CP) is a group of permanent disorders affecting the development of movement and posture, resulting in activity limitations due to non-progressive disturbances in the developing fetal or infant brain. Children with cerebral palsy commonly experience impaired upper extremity function, reduced bimanual coordination, and poor trunk control, which may interfere with activities of daily living and functional independence. Hand–Arm Bimanual Intensive Therapy (HABIT) promotes task-specific and repetitive bimanual practice to improve upper extremity function, whereas Core Stability Exercises aim to enhance proximal stability and postural control to facilitate functional upper limb movements. Although both interventions are used in pediatric neurorehabilitation, evidence directly comparing their effects remains limited.

Objective: To compare the effectiveness of Hand–Arm Bimanual Intensive Therapy and Core Stability Exercises in improving upper extremity function among children with cerebral palsy.

Methods: A comparative study was conducted among children with spastic cerebral palsy who fulfilled the specified inclusion and exclusion criteria. Twenty participants were allocated into two groups, with 10 participants in each group. Group A received Hand–Arm Bimanual Intensive Therapy, while Group B received Core Stability Exercises. Both groups underwent intervention for 45–50 minutes per session, three sessions per week, for a total duration of 8 weeks. Upper extremity function and trunk control were assessed before and after the intervention using the Jebsen–Taylor Hand Function Test (JTHFT) and the Trunk Control Measurement Scale (TCMS), respectively.

Results: Twenty children with cerebral palsy completed the study. Both groups demonstrated significant improvements following the intervention. The mean TCMS score increased from 32.20 ± 2.14 to 45.60 ± 2.06 in Group A and from 32.50 ± 1.58 to 39.50 ± 1.58 in Group B. Similarly, the mean JTHFT completion time decreased from 90.90 ± 3.95 seconds to 68.70 ± 3.40 seconds in Group A and from 92.70 ± 2.75 seconds to 81.90 ± 2.51 seconds in Group B. These findings indicate improvement in trunk control and hand function in both groups, with greater improvement observed in Group A.

Conclusion: Both Hand–Arm Bimanual Intensive Therapy and Core Stability Exercises demonstrated improvements in upper extremity function and trunk control among children with cerebral palsy following an 8-week intervention.

Greater improvement was observed in the Hand–Arm Bimanual Intensive Therapy group, particularly in JTHFT and TCMS outcomes. The findings suggest that HABIT may provide beneficial effects on functional upper limb performance in children with cerebral palsy.

Keywords: Cerebral Palsy; Hand–Arm Bimanual Intensive Therapy; Core Stability Exercises; Upper Extremity Function; Trunk Control; Jebsen–Taylor Hand Function Test; Trunk Control Measurement Scale.

Introduction

Cerebral palsy (CP) is a group of permanent disorders of the development of movement and posture, causing activity limitations that are attributed to non-progressive disturbances occurring in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication, behaviour, epilepsy, and secondary musculoskeletal problems. Cerebral palsy is the most common cause of physical disability in childhood, with a worldwide prevalence of approximately 2–3 cases per 1,000 live births. The condition affects children throughout their lifespan and significantly limits functional independence and quality of life [2].

The prevalence of cerebral palsy is higher in low- and middle-income countries because of inadequate prenatal, perinatal, and neonatal healthcare services. Prematurity, low birth weight, birth asphyxia, neonatal infections, intracranial haemorrhage, and congenital brain malformations are among the major risk factors associated with cerebral palsy. Children with cerebral palsy commonly present with abnormal muscle tone, impaired postural control, delayed motor development, muscle weakness, poor balance, reduced trunk stability, impaired upper extremity function, and limitations in performing activities of daily living. Among these impairments, upper extremity dysfunction considerably affects functional independence by limiting reaching, grasping, object manipulation, self-care activities, and participatimon in school and play [1].

Physiotherapy plays an essential role in the rehabilitation of children with cerebral palsy by promoting motor development, improving functional independence, preventing secondary musculoskeletal complications, and enhancing quality of life. Rehabilitation programmes focus on improving muscle strength, trunk stability, postural control, balance, motor learning, and functional task performance through repetitive practice and neuroplastic adaptations. Various therapeutic interventions such as neurodevelopmental treatment, constraint-induced movement therapy, task-oriented training, Hand–Arm Bimanual Intensive Therapy, trunk control exercises, and Core Stability Exercises have been widely used to improve upper extremity function in children with cerebral palsy [3].

Hand–Arm Bimanual Intensive Therapy (HABIT) is a task-oriented motor learning intervention that emphasizes repetitive, intensive, and meaningful use of both upper limbs during functional activities. The programme includes reaching, grasping, lifting, stacking, bead threading, object manipulation, and simulated activities of daily living that require coordinated use of both hands. Repeated bimanual practice enhances motor planning, bilateral coordination, sensory integration, cortical reorganization, and activity-dependent neuroplasticity, thereby improving upper extremity function and functional independence in children with cerebral palsy [4].

Core Stability Exercises focus on strengthening the muscles of the trunk, abdomen, pelvis, and lower back to improve proximal stability and postural control. A stable trunk provides an effective base for distal upper limb movements and enhances balance, coordination, and functional performance. Exercises such as pelvic tilts, bridging, Swiss ball training, side planks, single-leg stance, and dynamic balance activities improve trunk control, postural alignment, neuromuscular coordination, and movement efficiency. Improved proximal stability facilitates better reaching, grasping, and manipulation of objects during daily functional activities.

Although both Hand–Arm Bimanual Intensive Therapy and Core Stability Exercises have demonstrated beneficial effects on upper extremity function in children with cerebral palsy, only a limited number of studies have directly compared these interventions. Therefore, the present study was undertaken to compare the effectiveness of Hand–Arm Bimanual Intensive Therapy and Core Stability Exercises in improving upper extremity function among children with cerebral palsy and to determine the more effective treatment approach for clinical rehabilitation.

Methods

Ethical approval for this study was obtained from the Institutional Ethics Committee of Revathi Institute of Physiotherapy before commencement of the study. The study was conducted in accordance with the ethical

principles of the Declaration of Helsinki. Written informed consent was obtained from the parents/guardians of all participants prior to enrollment. Ethical Clearance No. (IEC-RIPT/DT/21/0521)

Study Design and Participants

A comparative study was conducted among 20 children with spastic cerebral palsy who fulfilled the inclusion and exclusion criteria. Participants were selected using purposive sampling and were randomly allocated into two groups through the lottery method. Group A received Hand–Arm Bimanual Intensive Therapy (HABIT), while Group B received Core Stability Exercises. Both groups received their respective interventions for a total duration of 8 weeks.

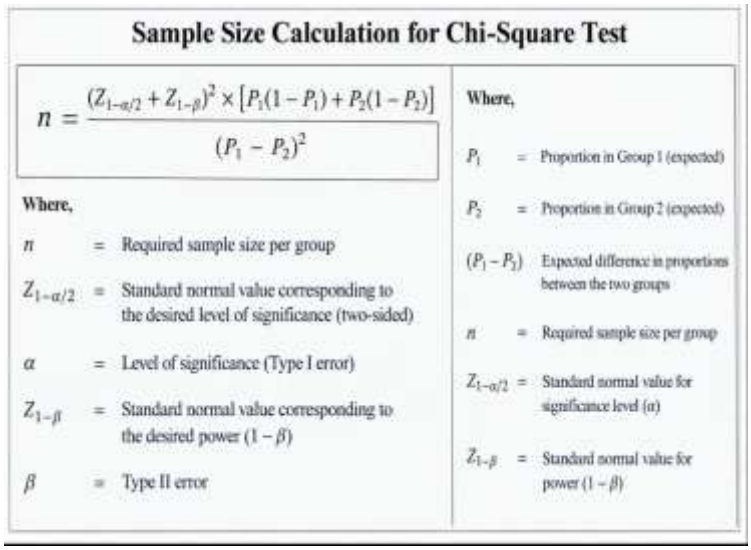


Fig 1. Chi-square Test for Sample Size Calculation

The required sample size was determined using the chi-square test for sample size calculation. A total of 20 participants were included in the study, with 10 participants allocated to Group A and 10 participants allocated to Group B.

Inclusion and Exclusion Criteria

Children aged 4–17 years diagnosed with spastic cerebral palsy, classified within GMFCS levels I–III and MACS levels I–III, who were able to sit independently and follow simple verbal instructions were included in the study.

Children with severe cognitive impairment, uncontrolled epilepsy, severe visual or auditory impairment, fixed contractures or severe musculoskeletal deformities, those receiving concurrent structured upper-limb rehabilitation, and those who had undergone orthopaedic surgery, neurosurgery, or botulinum toxin treatment within the previous six months were excluded from the study.

Intervention

Participants allocated to Group A received Hand–Arm Bimanual Intensive Therapy (HABIT) for 45–50 minutes per session, three sessions per week for a total duration of 8 weeks, with a 5-minute rest interval between activities. The programme consisted of intensive, task-specific bimanual activities that progressively challenged bilateral upper-limb coordination and functional hand performance. Day 1 included bilateral reaching and grasping, ball holding and passing, and lifting and placing objects. Day 2 included stacking blocks, opening and closing containers, and simulated activities of daily living. Day 3 included bead threading, paper tearing and folding, and bimanual toy manipulation. The difficulty of each activity was progressively increased according to the child's functional ability and tolerance. The therapist provided verbal guidance and manual assistance when required, with continuous supervision to encourage active participation, improve bilateral coordination, enhance motor planning, and facilitate functional upper-extremity performance through repetitive motor practice.

Participants allocated to Group B received Core Stability Exercises for 45–50 minutes per session, three sessions per week for a total duration of 8 weeks, with a 5-minute rest interval between exercises. The programme progressively emphasized trunk stability, postural control, balance, and proximal control. Day 1 included breathing control with seated postural alignment, pelvic tilts, pelvic bridging, and close-

feet standing. Day 2 included bridging with arm movements, sitting balance on a Swiss ball, and the modified Hundred exercise. Day 3 included single-leg stance, side plank, and walking heel-to-toe with coordinated arm movements. All exercises were performed under therapist supervision using appropriate repetitions, sets, and holding times according to the child's functional ability and tolerance, progressing from basic trunk stabilization exercises to dynamic functional activities. The programme aimed to improve proximal trunk stability, postural alignment, balance, neuromuscular coordination, and upper-extremity function by providing a stable base for distal limb movement.

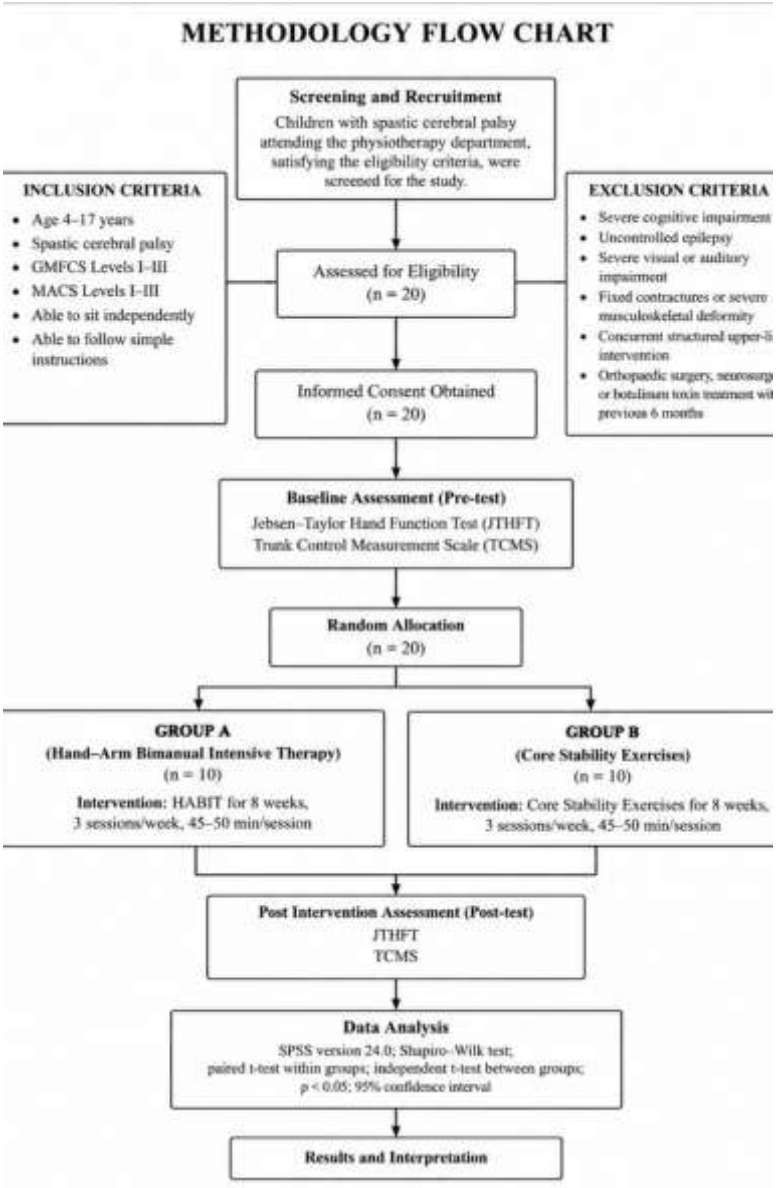


Fig 2. Methodology Flow Chart

Outcome measures

The Jebsen–Taylor Hand Function Test (JTHFT) and Trunk Control Measurement Scale (TCMS) were used to assess upper extremity function and trunk control among children with cerebral palsy. Outcome measures were assessed before and after completion of the 8-week intervention program.

Statistical analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS), version 24, with a significance level of $p < 0.05$ and a 95% confidence interval set for all analyses. The Shapiro–Wilk test was used to determine the normality of the data. In this study, the Shapiro–Wilk test showed that the data were normally distributed for the dependent variables at $p > 0.05$. Hence, parametric tests were adopted.

Paired t-test was used to determine the statistical difference within the groups, and independent t-test was used to determine the statistical difference between the groups.

Results

A total of 20 children with cerebral palsy were included in the study and divided into two equal groups (n = 10 each). Group A received Hand–Arm Bimanual Intensive Therapy (HABIT), whereas Group B received Core Stability Exercises. Both groups received treatment for 45–50 minutes per session, 3 days per week, for a total duration of 8 weeks, with a 5-minute rest interval. Jebsen–Taylor Hand Function Test and Trunk Control Measurement Scale were assessed before and after the intervention.

Jebsen–Taylor Hand Function Test (JTHFT)

Within-group analysis demonstrated significant improvements in Jebsen–Taylor Hand Function Test scores following the intervention in both groups ($p \leq 0.05$). Group A improved from a mean score of 90.90 ± 3.95 at baseline to 68.70 ± 3.40 after the intervention, whereas Group B improved from 92.70 ± 2.75 to 81.90 ± 2.51. Since the JTHFT is a timed test, the reduction in completion time indicates improvement in functional hand performance.

Between-group comparison showed no significant difference in pre-test JTHFT scores between Group A and Group B ($t = -1.18$, $df = 18$, $p = 0.253$), indicating that both groups were comparable before the intervention. However, a statistically significant difference was observed between the groups in the post-test JTHFT scores ($t = -0.986$, $df = 18$, $p = 0.001$). Group A demonstrated a lower post-test mean completion time than Group B, indicating greater improvement in functional hand performance following HABIT.

Trunk Control Measurement Scale (TCMS)

Within-group analysis demonstrated significant improvements in Trunk Control Measurement Scale scores following the intervention in both groups ($p = 0.001$). Group A improved from a mean score of 32.20 ± 2.14 at baseline to 45.60 ± 2.06 after the intervention, whereas Group B improved from 32.50 ± 1.58 to 39.50 ± 1.58. The improvement in TCMS scores was greater in Group A than in Group B.

Between-group comparison showed no significant difference in baseline TCMS scores between Group A and Group B ($t = -0.355$, $df = 18$, $p = 0.726$), indicating that both groups were comparable before the intervention. However, post-intervention TCMS scores differed significantly between the groups ($t = 7.41$, $df = 18$, $p = 0.001$), with Group A demonstrating higher TCMS scores than Group B, indicating greater improvement in trunk control following HABIT.

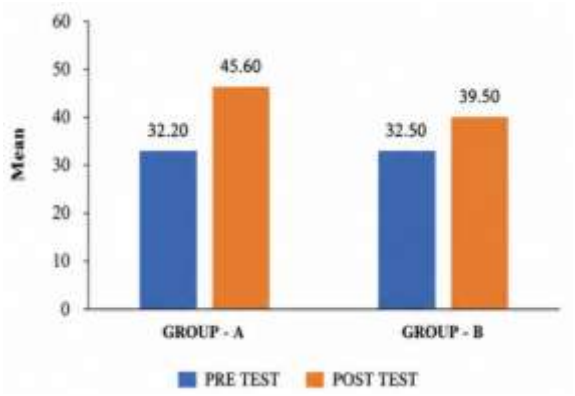
Within-group analysis demonstrated significant differences between pre-test and post-test values for both groups. For JTHFT, Group A showed a t-value of 21.40 and Group B showed a t-value of -18.14, with $p = 0.001$ for both groups. For TCMS, Group A showed a t-value of 60.60 and Group B showed a t-value of 11.10, with $p = 0.001$ for both groups.

Table 1: Mean value, standard deviation, t value and p value of Trunk Control Measurement Scale between pre-test and post-test values within Group A and Group B.

TEST	GROUP - A		GROUP - B		t - TEST	df	SIGNIFICANCE
	MEAN	S.D	MEAN	S.D			
PRE TEST	32.20	2.14	32.50	1.58	-.355	18	.726*
POST TEST	45.60	2.06	39.50	1.58	7.41	18	.001**

(*- $P > 0.05$ - Not Significant) & (**- $P \leq 0.05$ - Significant).

Graph 1: Graphical representation between pre-test and post-test values of the Trunk Control Measurement Scale within Group A and Group B.



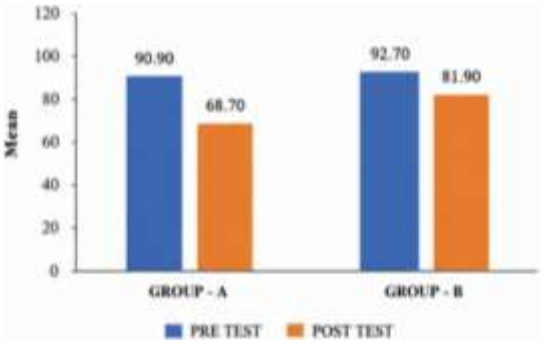
Within-group analysis of the Jebsen–Taylor Hand Function Test revealed statistically significant improvement in both groups following the intervention. Group A demonstrated greater improvement in upper extremity function compared with Group B. Comparison of pre-test and post-test values showed significant differences at $P \leq 0.05$.

Table 2: Mean value, standard deviation, t value and p value of the Jebsen–Taylor Hand Function Test between pre-test and post-test values within Group A and Group B.

TEST	GROUP - A		GROUP - B		t - TEST	df	SIGNIFICANCE
	MEAN	S.D	MEAN	S.D			
PRE TEST	90.90	3.95	92.70	2.75	-1.18	18	.253*
POST TEST	68.70	3.40	81.90	2.51	-9.86	18	.001**

(*- P > 0.05 - Not Significant) & (**- P ≤ 0.05 - Significant).

Graph 2: Graphical representation between pre-test and post-test values of the Jebsen–Taylor Hand Function Test within Group A and Group B.



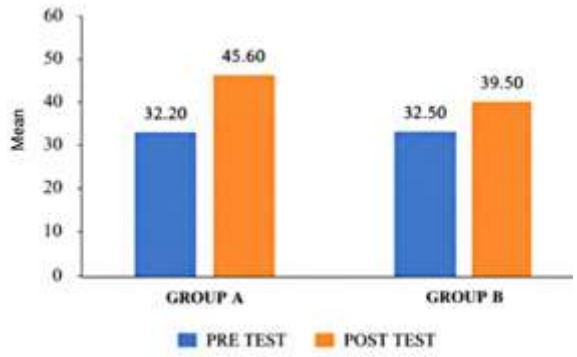
Between-group comparison using the Trunk Control Measurement Scale demonstrated no statistically significant difference between the groups at pre-test. However, post-test comparison revealed that Group A achieved higher TCMS scores than Group B, indicating greater improvement in trunk control following Hand–Arm Bimanual Intensive Therapy. Therefore, the null hypothesis was rejected.

Table 3: Mean value, standard deviation, t value, degree of freedom and p value between Group A and Group B for the Trunk Control Measurement Scale.

GROUPS	PRE TEST		POST TEST		t - TEST	SIGNIFICANCE
	MEAN	S.D	MEAN	S.D		
GROUP- A	32.20	2.14	45.60	2.06	60.60	.001**
GROUP- B	32.50	1.58	39.50	1.58	11.10	.001**

(**- P ≤ 0.05 - Significant).

Graph 3: Graphical representation of pre-test and post-test values of the Trunk Control Measurement Scale between Group A and Group B.



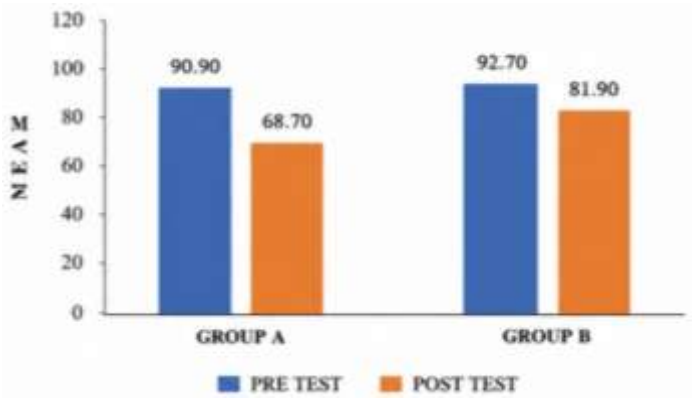
Between-group comparison of the Jebsen–Taylor Hand Function Test demonstrated a statistically significant difference between the two interventions. The post-test mean JTHFT score was lower in Group A than in Group B, indicating superior improvement in upper extremity function following Hand–Arm Bimanual Intensive Therapy. Based on these findings, the null hypothesis was rejected, and it was concluded that although both interventions improved upper extremity function, Hand–Arm Bimanual Intensive Therapy produced superior outcomes compared with Core Stability Exercises.

Table 4: Mean value, standard deviation, t value, degree of freedom and p value between Group A and Group B for the Jebsen–Taylor Hand Function Test.

GROUPS	PRE TEST		POST TEST		t - TEST	SIGNIFICANCE
	MEAN	S.D	MEAN	S.D		
GROUP- A	90.90	3.95	68.70	3.40	21.40	.001**
GROUP- B	92.70	2.75	81.90	2.51	-18.14	.001**

(**- P ≤ 0.05 - Significant)

Graph 4: Graphical representation of pre-test and post-test values of the Jebsen–Taylor Hand Function Test between Group A and Group B.



Discussion

The present study compared the effectiveness of Hand–Arm Bimanual Intensive Therapy (HABIT) and Core Stability Exercises in improving upper extremity function among children with cerebral palsy. Both interventions resulted in improvements in upper extremity function and trunk control following an 8-week training program conducted three times per week. However, participants who received HABIT demonstrated greater improvement in Trunk Control Measurement Scale (TCMS) scores and lower Jebsen–Taylor Hand Function Test (JTHFT) completion times compared to those who received Core Stability Exercises, indicating greater improvement in hand function and trunk control in the HABIT group.

The greater improvement observed with HABIT may be attributed to its task-specific, repetitive, and bimanual training approach. The intervention involved bilateral reaching, grasping, ball handling, object manipulation, stacking, threading, paper folding and simulated activities of daily living. Repeated practice of these functional activities may improve bilateral coordination, hand dexterity, grasp and release, object manipulation and performance of functional activities. In contrast, Core Stability Exercises

primarily focused on improving trunk muscle activation, postural stability, proximal control and balance, which may contribute indirectly to improved upper extremity function.

The findings of this comparative study indicate that both Hand–Arm Bimanual Intensive Therapy and Core Stability Exercises are beneficial interventions for improving upper extremity function and trunk control in children with cerebral palsy following an 8-week rehabilitation program. However, participants who underwent HABIT demonstrated greater improvement in TCMS and JTHFT outcomes than those who received Core Stability Exercises. These findings suggest that HABIT may provide additional benefits in enhancing functional hand performance, bilateral coordination and trunk control in children with cerebral palsy.

Incorporating task-specific bimanual training into pediatric neurorehabilitation programs may improve functional upper-limb performance and participation in activities of daily living. Nevertheless, the findings should be interpreted with caution due to the small sample size and limited study setting. Future studies with larger sample sizes, participants from multiple centers, long-term follow-up and additional functional outcome measures are warranted to further evaluate the effectiveness of HABIT and Core Stability Exercises in children with cerebral palsy.

Conclusion

This study was conducted to compare the effectiveness of Hand–Arm Bimanual Intensive Therapy and Core Stability Exercises for improving upper extremity function among children with cerebral palsy. Twenty children with cerebral palsy were included in the study and were randomly divided into 2 groups. Group A was treated with Hand–Arm Bimanual Intensive Therapy and Group B was treated with Core Stability Exercises for 8 weeks. Upper extremity function and trunk control were assessed using the Jebsen–Taylor Hand Function Test and Trunk Control Measurement Scale before and after the intervention.

From the results, it was concluded that both Hand–Arm Bimanual Intensive Therapy and Core Stability Exercises improved upper extremity function and trunk control among children with cerebral palsy. The group treated with HABIT showed greater improvement in the measured outcomes compared with the Core Stability Exercise group. Hence, the findings of the present study indicate that HABIT may be a useful intervention for improving upper extremity function and trunk control among children with cerebral palsy.

Limitations and Recommendations

The present study had certain limitations. The sample size was relatively small, which may limit the generalizability of the findings. Psychological and behavioural factors that could influence the children's motivation, attention, cooperation and rehabilitation outcomes were not considered. In addition, the study was conducted over a limited duration, making it difficult to evaluate the long-term effects of the interventions. Furthermore, the study did not include long-term follow-up or parent-reported functional outcomes, which could have provided additional evidence regarding the sustained effectiveness of the interventions in improving upper extremity function and activities of daily living.

Based on these limitations, future studies should include a larger sample size and participants from different age groups and varying levels of cerebral palsy severity to improve the applicability of the findings. Long-term studies are recommended to evaluate the sustained effects of Hand–Arm Bimanual Intensive Therapy and Core Stability Exercises. Future research should also incorporate additional standardized clinical assessment tools to evaluate hand function, trunk control, activities of daily living, participation and quality of life. Furthermore, future studies may investigate the effectiveness of combining HABIT with other evidence-based pediatric neurorehabilitation approaches.

Conflict of Interest

Some individuals were not willing to participate in the study, and the number of children fulfilling the inclusion and exclusion criteria was limited within the study region.

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Authors Contribution

Maha Rajesh Kumar M., Conceptualization, Methodology, Participant recruitment, Data collection, Formal analysis, Manuscript drafting.
Dr. Athira M: Supervision, Methodology validation, Critical revision of the manuscript, Final approval of the manuscript.
Dr. P. Bright Alwin Victor: Research guidance, Manuscript review, Administrative support, Final approval of the manuscript.

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