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IMPACT OF HAND AND ARM BIMANUAL INTENSIVE THERAPY AMONG CHILDREN WITH UNILATERAL SPASTIC CEREBRAL PALSY

Original Research

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ABSTRACT

Background: Unilateral spastic cerebral palsy (USCP) is a neurological condition that primarily affects motor function on one side of the body, leading to significant impairments in hand and arm coordination, daily activities, and overall quality of life. Conventional rehabilitation approaches often focus on unimanual training, limiting the development of bimanual skills necessary for functional independence. Hand and Arm Bimanual Intensive Therapy (HABIT) has emerged as a promising intervention aimed at improving bilateral coordination through structured, task-oriented activities by leveraging neuroplasticity.

Objective: This study aimed to evaluate the effects of HABIT on motor function, functional independence, and quality of life in children with USCP, providing evidence for its therapeutic efficacy.

Methods: A randomized controlled trial was conducted on 20 children diagnosed with USCP, recruited from Children's Hospital Faisalabad using a non-probability sampling technique. Participants were randomly allocated into two groups: Group A received HABIT, while Group B served as the control group and underwent conventional therapy, including passive range of motion exercises and stretching. The intervention was administered over 12 weeks, with three sessions per week. Outcome measures included the Bimanual Performance Test (BPM), Functional Independence Measure (FIM), and Quality of Life Score (QoL). Data were analyzed using SPSS, with statistical significance set at $p < 0.05$.

Results: Post-intervention assessments demonstrated significantly greater improvements in Group A compared to Group B. The BPM scores increased from 25.6 ± 4.2 to 32.1 ± 3.9 in Group A, while Group B showed a lesser improvement from 24.8 ± 3.8 to 27.5 ± 4.0 ($p < 0.001$). FIM scores improved from 40.2 ± 5.3 to 48.7 ± 4.8 in Group A, whereas Group B increased from 39.7 ± 5.1 to 43.1 ± 5.0 ($p < 0.001$). Similarly, QoL scores improved from 65.3 ± 7.4 to 72.9 ± 6.2 in Group A, compared to 64.2 ± 7.1 to 66.8 ± 7.0 in Group B ($p < 0.001$).

Conclusion: The findings support the efficacy of HABIT in significantly improving bimanual motor function, functional independence, and quality of life in children with USCP. The structured, intensive nature of the intervention suggests its potential as an effective rehabilitation strategy for pediatric neurorehabilitation.

Keywords: Activities of daily living, Cerebral palsy, Children, Functional independence, Motor skills, Quality of life, Rehabilitation.

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INTRODUCTION

Unilateral spastic cerebral palsy (USCP) is a subtype of cerebral palsy that primarily affects one side of the body, leading to motor impairments that hinder the ability to perform essential developmental tasks. Children with USCP experience difficulties in hand and arm movement, reduced strength, impaired bimanual coordination, and challenges in executing tasks requiring bilateral hand use. These limitations significantly impact their quality of life, affecting learning, interpersonal relationships, and personal care (1–3). Cerebral palsy remains the most prevalent childhood motor disability, occurring in approximately 2 to 3 per 1,000 live births worldwide, translating to an estimated 17 million affected individuals globally (4). In Pakistan, the prevalence mirrors global statistics, yet limited access to healthcare leads to underreporting and delayed diagnosis and interventions, exacerbating the condition's long-term impact (5–7). In recent years, advancements in rehabilitation have shifted focus from traditional approaches to functional, neuroplasticity-based interventions designed to optimize motor function and independence (8, 9). Among these, Hand and Arm Bimanual Intensive Therapy (HABIT) has emerged as an evidence-based approach that targets bimanual coordination through structured, goal-oriented training. Unlike conventional therapies that emphasize unimanual task performance, HABIT engages both hands simultaneously to facilitate functional improvement in everyday activities (10–12). This therapy capitalizes on neuroplasticity by reorganizing neural pathways through repetitive, meaningful activities, fostering motor skill development, and promoting self-sufficiency (11, 13, 14).

Research has demonstrated that HABIT leads to notable improvements in bilateral hand use, making tasks such as dressing, eating, and playing more manageable while reducing frustration in children with USCP (15). By enhancing motor function and self-care abilities, this therapy not only promotes independence in activities of daily living but also alleviates caregiver burden, ultimately contributing to a more supportive and less stressful family environment. However, despite its established benefits, HABIT remains underutilized, particularly in regions with limited access to specialized rehabilitation services. This study aims to evaluate the impact of HABIT on functional outcomes in children with USCP, addressing gaps in existing research and reinforcing the significance of bimanual training in neurorehabilitation.

METHODS

This randomized controlled trial was conducted to evaluate the effectiveness of Hand and Arm Bimanual Intensive Therapy (HABIT) in children with unilateral spastic cerebral palsy (USCP). A total of 20 children diagnosed with USCP were recruited from Children's Hospital Faisalabad using a non-probability sampling technique. Participants were aged between 6 and 12 years, classified as Level II on the Gross Motor Function Classification System (GMFCS), and had the ability to follow instructions and actively participate in therapy sessions. Those who had received intensive hand or bimanual therapy within the preceding six months, had severe cognitive impairments or significant neurological comorbidities affecting their ability to engage in the study, had undergone upper limb orthopedic surgery or botulinum toxin injection within the past six months, or had advanced contractures and deformities significantly limiting upper limb motion were excluded. Additionally, children unable to attend therapy consistently were not considered for participation. Participants were randomly assigned into two groups. Group A received HABIT, focusing on task-specific, goal-oriented bimanual activities, while Group B served as the control group and received conventional therapy consisting of passive range of motion exercises and stretching. Both groups underwent therapy for a duration of 12 weeks, with three sessions per week. The study strictly adhered to ethical guidelines, ensuring informed consent was obtained from parents or legal guardians before participation. Ethical approval was granted by the institutional review board (IRB) of the respective institution.

Outcome measures included the Bimanual Performance Test (BPM) to assess hand function, the Functional Independence Measure (FIM) to evaluate self-care and daily living activities, and the Quality of Life Score (QoL) to determine the impact of therapy on overall well-being. Data collection was conducted at baseline and post-intervention to assess functional improvements. Statistical analysis was performed using SPSS, with appropriate statistical tests applied to determine the significance of differences between the intervention and control groups. The study was conducted from March 2024 to November 2024. Randomization was conducted using a computer-generated random sequence to ensure unbiased allocation of participants into the intervention and control groups. Allocation concealment was maintained through sealed opaque envelopes to prevent selection bias. Blinding of assessors was implemented to enhance the reliability of outcome evaluations. Data analysis was performed using SPSS, with descriptive statistics used to summarize

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baseline characteristics and inferential statistics, including paired and independent t-tests, applied to compare pre- and post-intervention outcomes. A p-value of <0.05 was considered statistically significant.

RESULTS

The study included 20 children diagnosed with unilateral spastic cerebral palsy (USCP), with a mean age of 8.4 ± 1.2 years in the intervention group and 8.6 ± 1.4 years in the control group. Gender distribution was comparable, with 12 males and 8 females in the intervention group, while the control group comprised 10 males and 10 females. The affected side distribution was slightly varied, with left-sided involvement in 14 participants and right-sided involvement in 6 participants in the intervention group, whereas the control group had 13 left-sided and 7 right-sided cases. All participants were classified as Level II on the Gross Motor Function Classification System (GMFCS). Within-group analysis demonstrated significant improvements in all outcome measures following the intervention. The intervention group showed an increase in Bimanual Performance Test (BPM) scores from 25.6 ± 4.2 at baseline to 32.1 ± 3.9 post-intervention, whereas the control group exhibited a more modest improvement from 24.8 ± 3.8 to 27.5 ± 4.0. Functional Independence Measure (FIM) scores improved from 40.2 ± 5.3 to 48.7 ± 4.8 in the intervention group, while the control group recorded a lesser increase from 39.7 ± 5.1 to 43.1 ± 5.0. Similarly, the Quality of Life Score (QoL) rose from 65.3 ± 7.4 to 72.9 ± 6.2 in the intervention group, compared to a more limited increase from 64.2 ± 7.1 to 66.8 ± 7.0 in the control group.

Between-group analysis further highlighted the superiority of the intervention. The mean change in BPM scores was significantly higher in the intervention group (6.5 ± 1.5) compared to the control group (2.7 ± 1.3), with a p-value of < 0.001. Similarly, FIM scores improved by 8.5 ± 1.2 in the intervention group versus 3.4 ± 1.1 in the control group ($p < 0.001$). The intervention group also exhibited greater improvements in QoL scores (7.6 ± 1.4) than the control group (2.6 ± 1.2), with statistical significance ($p < 0.001$). These findings indicate that Hand and Arm Bimanual Intensive Therapy (HABIT) led to substantial functional and quality-of-life improvements compared to traditional therapy.

Table 1: Demographic Characteristics

Characteristics	Group A (HABIT)	Group B (Control)
Age (years)	8.4 ± 1.2	8.6 ± 1.4
Gender (M/F)	12/8	10/10
Affected Side (Left/Right)	14/6	13/7
Gross Motor Function Classification System (GMFCS) Level	II	II

Table 2 within-group analysis of outcome measures before and after the intervention.

Outcome Measures	Group A (Pre)	Group A (Post)	Group B (Pre)	Group B (Post)
Bimanual Performance Test (BPM)	25.6 ± 4.2	32.1 ± 3.9	24.8 ± 3.8	27.5 ± 4.0
Functional Independence Measure (FIM)	40.2 ± 5.3	48.7 ± 4.8	39.7 ± 5.1	43.1 ± 5.0
Quality of Life Score (QoL)	65.3 ± 7.4	72.9 ± 6.2	64.2 ± 7.1	66.8 ± 7.0

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Table 3: between-group analysis of changes in outcome measures, including statistical significance (p-values).

Outcome Measures	Group A	Group B	p-value
Bimanual Performance Test (BPM)	6.5 ± 1.5	2.7 ± 1.3	< 0.001
Functional Independence Measure (FIM)	8.5 ± 1.2	3.4 ± 1.1	< 0.001
Quality of Life Score (QoL)	7.6 ± 1.4	2.6 ± 1.2	< 0.001

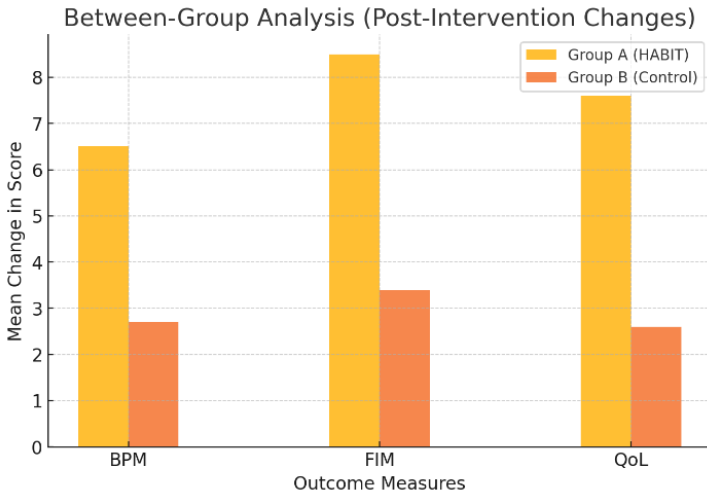


Figure 1 Group Analysis of Post Intervention Changes

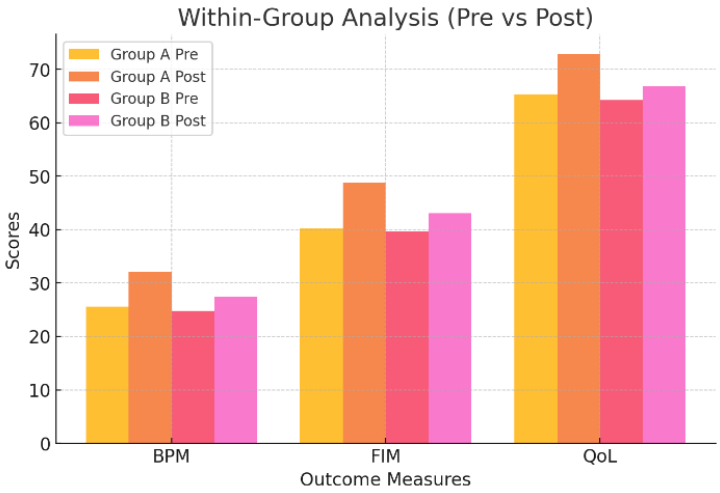


Figure 2 Group Analysis Pre Vs Post

DISCUSSION

The present randomized controlled trial evaluated the effects of Hand and Arm Bimanual Intensive Therapy (HABIT) on functional outcomes in children with unilateral spastic cerebral palsy (USCP). Both intervention and control groups were comparable in baseline characteristics, including age, gender distribution, and affected side, ensuring a balanced comparison and minimizing bias. All participants had mild to moderate motor impairments classified as GMFCS Level II, further supporting the reliability of outcome assessments. The within-group analysis revealed significant improvements in bimanual performance, functional independence, and quality of life following HABIT. The intervention group exhibited a substantial increase in Bimanual Performance Test (BPM) scores, from 25.6 ± 4.2 to 32.1 ± 3.9, whereas the control group demonstrated a comparatively lower improvement from 24.8 ± 3.8 to 27.5 ± 4.0. Functional Independence Measure (FIM) scores improved by 8.5 ± 1.2 points in the intervention group, while the control group showed an increase of only 3.4 ± 1.1 points. Similarly, Quality of Life (QoL) scores increased by 7.6 ± 1.4 points in the intervention group, in contrast to 2.6 ± 1.2 points in the control group. These findings align with prior research emphasizing the effectiveness of HABIT in enhancing motor skills, daily functional independence, and overall well-being in children with USCP (17, 18).

Between-group comparisons further reinforced the efficacy of HABIT, with statistically significant differences observed across all outcome measures. The mean change in BPM (6.5 ± 1.5 vs. 2.7 ± 1.3), FIM (8.5 ± 1.2 vs. 3.4 ± 1.1), and QoL (7.6 ± 1.4 vs. 2.6 ± 1.2) underscored the superiority of HABIT over conventional therapy. The statistical significance of these improvements ($p < 0.001$) highlights the strong impact of intensive bimanual training on functional recovery in USCP (19, 20). The study's strengths include its randomized controlled design, ensuring a rigorous assessment of the intervention's efficacy. The structured application of HABIT, with targeted task-oriented activities, provided a consistent framework for evaluating bimanual improvements. The use of standardized outcome measures, including BPM, FIM, and QoL scores, enhanced the reliability of findings. However, certain limitations warrant consideration. The small sample size may limit generalizability, necessitating further studies with larger cohorts. Additionally, the short intervention period of 12 weeks, while demonstrating significant results, does not account for long-term sustainability of improvements.

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Future research should incorporate extended follow-up periods to evaluate the persistence of gains and potential regression over time. Another limitation pertains to the lack of neuroimaging or objective biomarkers to substantiate the neuroplastic changes associated with HABIT. Incorporating advanced imaging techniques in future studies could provide deeper insights into the underlying neural mechanisms facilitating functional recovery.

Despite these limitations, the study reinforces the role of HABIT as a promising rehabilitation strategy for children with USCP, offering significant advantages over conventional therapy. Future research should explore individualized treatment protocols, incorporating variations in intensity and duration to optimize functional outcomes. The integration of home-based HABIT programs, coupled with caregiver training, may further enhance accessibility and adherence, ensuring sustained benefits beyond clinical settings.

CONCLUSION

The findings of this study strongly support the efficacy of Hand and Arm Bimanual Intensive Therapy (HABIT) in enhancing motor performance, functional independence, and overall quality of life in children with unilateral spastic cerebral palsy. The intervention demonstrated significant therapeutic potential by addressing bimanual coordination deficits through structured, task-oriented activities. These results highlight the importance of incorporating intensive bimanual training into rehabilitation programs as a targeted approach to improve daily functional abilities and promote greater independence. By reinforcing motor learning principles and harnessing neuroplasticity, HABIT offers a valuable strategy for optimizing long-term outcomes in pediatric neurorehabilitation.

AUTHOR CONTRIBUTIONS

Author	Contribution
Menahil Ahmed*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Yasir Ali Kazmi	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Hafiz Muhammad Umair Ali	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Namra Saleem	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Abeer Bhatti	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Maria Sajid	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Ahmad Saeed Choudhary	Contributed to study concept and Data collection Has given Final Approval of the version to be published

REFERENCES

1. Ma D, Zeng RR, Chan SS, Pan Y, Zhang JJ. Case report: Movement-related neuroplasticity in a patient after spinal cord injury in response to task-oriented bimanual training. Frontiers in Human Neuroscience. 2025.

2. Lee KT, Cheng KW, Yang YC, Wang WL. Magic-themed motor training for daily bimanual task performance in children with unilateral spastic cerebral palsy: A systematic review and meta-analysis. Developmental Medicine & Child Neurology. 2025;67(1):49-58.

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3. Herron MS, Wang L, von Bartheld CS. Prevalence and types of strabismus in cerebral palsy: A global and historical perspective based on a systematic review and meta-analysis. Ophthalmic Epidemiology. 2024:1-18.

4. de Tournai AC, Herman E, Ebner-Karestinos D, Gathy E, Araneda R, Renders A, et al. Hand-Arm Bimanual Intensive Therapy Including Lower Extremities in Infants With Unilateral Cerebral Palsy: A Randomized Clinical Trial. JAMA network open. 2024;7(11):e2445133-e.

5. Araneda R, Ebner-Karestinos D, Paradis J, Klöcker A, Saussez G, Demas J, et al. Changes induced by early hand-arm bimanual intensive therapy including lower extremities in young children with unilateral cerebral palsy: a randomized clinical trial. JAMA pediatrics. 2024;178(1):19-28.

6. Steinbusch CV, Defesche A, van der Leij B, Rameckers EA, Knijnenburg AC, Vermeulen JR, et al. The Effect of Bimanual Intensive Functional Training on Somatosensory Hand Function in Children with Unilateral Spastic Cerebral Palsy: An Observational Study. Journal of Clinical Medicine. 2023;12(4):1595.

7. Liang K-J, Chen H-L, Huang C-W, Wang T-N. Efficacy of Constraint-Induced Movement Therapy Versus Bimanual Intensive Training on Motor and Psychosocial Outcomes in Children With Unilateral Cerebral Palsy: A Randomized Trial. The American Journal of Occupational Therapy. 2023;77(4):7704205030.

8. Bingol H, Kerem Gunel M, Alkan H. The efficacy of two models of intensive upper limb training on health-related quality of life in children with hemiplegic cerebral palsy mainstreamed in regular schools: A double-blinded, randomized controlled trial. Physiotherapy Theory and Practice. 2023;39(1):10-25.

9. Sawyer S. Hand-Arm Bilateral Intensive Training Compared to Constraint Induced Movement Therapy for Improving Bimanual Performance and Quality of Life in Children with Unilateral Spastic Cerebral Palsy: A Meta-Analysis: California State University, Fresno; 2022.

10. Bingöl H, Günel MK. Comparing the effects of modified constraint-induced movement therapy and bimanual training in children with hemiplegic cerebral palsy mainstreamed in regular school: A randomized controlled study. Archives de Pédiatrie. 2022;29(2):105-15.

11. Robert MT, Gutterman J, Ferre CL, Chin K, Brandao MB, Gordon AM, et al. Corpus callosum integrity relates to improvement of upper-extremity function following intensive rehabilitation in children with unilateral spastic cerebral palsy. Neurorehabilitation and neural repair. 2021;35(6):534-44.

12. Palomo-Carrión R, Lirio-Romero C, Ferri-Morales A, Jovellar-Isiegas P, Cortés-Vega M-D, Romay-Barrero H. Combined intensive therapies at home in spastic unilateral cerebral palsy with high bimanual functional performance. What do they offer? A comparative randomised clinical trial. Therapeutic advances in chronic disease. 2021;12:20406223211034996.

13. Jain T, Bisen R, Ranade P. Effectiveness Of Modified Constraint-Induced Movement Therapy Compared To Hand-Arm Bimanual Intensive Therapy On Quality Of Upper Extremity Function In Hemiplegic Cerebral Palsy Children-An Experimental Study. National Journal of Integrated Research in Medicine. 2021;12(2).

14. Friel KM, Ferre CL, Brandao M, Kuo H-C, Chin K, Hung Y-C, et al. Improvements in upper extremity function following intensive training are independent of corticospinal tract organization in children with unilateral spastic cerebral palsy: a clinical randomized trial. Frontiers in Neurology. 2021;12:660780.

15. Ouyang R-G, Yang C-N, Qu Y-L, Koduri MP, Chien C-W. Effectiveness of hand-arm bimanual intensive training on upper extremity function in children with cerebral palsy: A systematic review. European Journal of Paediatric Neurology. 2020;25:17-28.

16. Hung Y-C, Spingarn A, Friel KM, Gordon AM. Intensive unimanual training leads to better reaching and head control than bimanual training in children with unilateral cerebral palsy. Physical & Occupational Therapy In Pediatrics. 2020;40(5):491-505.

17. Hung Y-C, Shirzad F, Saleem M, Gordon AM. Intensive upper extremity training improved whole body movement control for children with unilateral spastic cerebral palsy. Gait & posture. 2020;81:67-72.

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18. Figueiredo PR, Mancini MC, Feitosa AM, Teixeira CM, Guerzoni VP, Elvrum AKG, et al. Hand–arm bimanual intensive therapy and daily functioning of children with bilateral cerebral palsy: a randomized controlled trial. Developmental Medicine & Child Neurology. 2020;62(11):1274-82.

19. Araneda R, Sizonenko S, Newman C, Dinomais M, Le Gal G, Nowak E, et al. Functional, neuroplastic and biomechanical changes induced by early Hand-Arm Bimanual Intensive Therapy Including Lower Extremities (e-HABIT-ILE) in pre-school children with unilateral cerebral palsy: study protocol of a randomized control trial. BMC neurology. 2020;20:1-10.

20. Alahmari K, Tedla JS, Sangadala DR, Mukherjee D, Reddy RS, Bairapareddy KC, et al. Effectiveness of hand-arm bimanual intensive therapy on hand function among children with unilateral spastic cerebral palsy: a meta-analysis. S. Karger AG Basel, Switzerland; 2020. p. 131-7.

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