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**EFFECTS OF ACTION OBSERVATION THERAPY AND MIRROR
THERAPY ON UPPER EXTREMITY FUNCTIONS IN CHILDREN
WITH UNILATERAL CEREBRAL PALSY:
A RANDOMIZED CONTROLLED STUDY
WITH 1 MONTH FOLLOW-UP**

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INTRODUCTION

- In children with unilateral CP, effective use of the arm and hand to reach, grasp, release and manipulate objects is often impaired because of conditions such as spasticity, sensory problems, and decreased muscle strength.
- Due to the limitation of arm and hand functions, it becomes difficult to use the upper extremity effectively in daily life.
- For this reason, children's occupational performance and participation in leisure time, education and self-care are negatively affected, causing their quality of life to decrease.

Sakzewski L, Ziviani J, Boyd R. Systematic review and meta-analysis of therapeutic management of upper-limb dysfunction in children with congenital hemiplegia. Pediatrics. 2009;123(6):e1111-e22.

INTRODUCTION

- When the literature is examined, it is seen that interventions such as Constraint Induced Movement Therapy (CIMT), Hand-Arm Bimanual Intensive Training (HABIT), Mirror Therapy (MT), Bimanual Training (BT), Virtual Reality (VR), Goal Directed Training Therapy (GDT) and Action Observation Therapy (AOT) are applied to improve upper extremity functions and ensure independence in daily living activities.
- However, although Action Observation Therapy (AOT) and Mirror Therapy (MT) are increasingly used as adjunct interventions, there is very limited evidence directly comparing their effects, especially when combined with bilateral training.

- Ramey SL, DeLuca SC, Stevenson RD, Conaway M, Darragh AR, Lo W. Constraint-induced movement therapy for cerebral palsy: A randomized trial. *Pediatrics*. 2021;148(5).
- 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.
- Park E-j, Baek S-h, Park S. Systematic review of the effects of mirror therapy in children with cerebral palsy. *Journal of Physical Therapy Science*. 2016;28(11):3227-31.
- Löwing K, Bexelius A, Brogren Carlberg E. Activity focused and goal directed therapy for children with cerebral palsy—do goals make a difference? *Disability and Rehabilitation*. 2009;31(22):1808-16.
- Abdelhaleem N, Taher S, Mahmoud M, Hendawy A, Hamed M, Mortada H, et al. Effect of action observation therapy on motor function in children with cerebral palsy: a systematic review of randomized controlled trials with meta-analysis. *Clinical Rehabilitation*. 2021;35(1):51-63.

AIM

The aim of this study was to investigate the effects of AOT and MT on occupational performance and satisfaction, goal-oriented skills, and upper extremity functions in children with unilateral CP.

METHOD

Participants

- 24 children with unilateral CP aged 6–12 years participated the study.
- Children were randomly assigned as
 - AOT group (n = 12)
 - MT group (n = 12)

Assessment Tools

1. Canadian Occupational Performance Measure (COPM)
 2. Goal Attainment Scale (GAS)
 3. Shriners Hospital Upper Extremity Evaluation (SHUEE)
 4. ABILHAND-Kids Questionnaire
- Assessment tools were applied before the intervention (T0), after the intervention (T1), and during a 1-month follow-up evaluation (T2).

Goal Attainment Scale (GAS)

- GAS evaluates individuals' achievement of their functional goals with a client-centered approach and enables the determination of priorities for intervention.
- The possible performance levels are determined for each activity target. The GAS consists of a total of 5 levels (-2, -1, 0, +1, +2).
- A score of 0 indicates the expected performance level, a score of +2 indicates a development level much above the expected performance
- *Turner-Stokes L. Goal attainment scaling (GAS) in rehabilitation: a practical guide. Clinical Rehabilitation. 2009;23(4):362-70.*

Goal Attainment Scale (GAS)

-2	No progress was made.
-1	Limited progress was made, but below expectations.
0	The target was not reached, but the expected progress was made.
+1	The target was reached and the expected progress was achieved.
+2	The target was exceeded and more progress than expected was made.

Shriners Hospital Upper Extremity Evaluation (SHUEE)

- SHUEE is a video-based assessment method that evaluates upper extremity functions in children with unilateral CP between the ages of 3 and 18.
- Dynamic functional analysis is performed to evaluate segmental orientation (thumb, fingers, wrist, forearm, elbow) in 16 activity tasks, while spontaneous functional analysis is evaluated in 9 activity tasks.
- Evaluates the ability to grasp and release the wrist in flexion, neutral, and extension positions

Davids JR et al. Validation of the Shriners Hospital for Children Upper Extremity Evaluation (SHUEE) for children with hemiplegic cerebral palsy. Jbjs. 2006;88(2):326-33.

ABILHAND-KIDS

- It is a questionnaire that defines the level of difficulty and ease in performing bilateral activities in children with CP between the ages of 6 and 15.
- A total of 21 activities, such as opening a jar, unscrewing a bottle cap, are scored on 3 levels (0=cannot be done, 1=difficult, 2=easy).
- The level of difficulty and ease of the activities is scored based on the parent's observations of their child.

Arnould C, Penta M, Renders A, Thonnard J-L. ABILHAND-Kids: a measure of manual ability in children with cerebral palsy. Neurology. 2004;63(6):1045-52.

Mirror Therapy

- Mirror Therapy is a neurorehabilitation technique in which the reflection of the **unaffected limb** is used to create the illusion of normal movement in the **affected limb**.
- Visual feedback activates the **mirror neuron system (MNS)**
- This activation supports **motor relearning** and cortical reorganization
- Contributes to improved **motor function** and reduced learned non-use



Ortega-Martínez, A. Et al. Motor and Sensory Benefits of Mirror Therapy in Children and Adolescents with Unilateral Cerebral Palsy: A Systematic Review and Meta-Analysis. Healthcare 2025, 13, 1538.

Action Observation Therapy (AOT)

- Used in **upper limb rehabilitation**, especially in **CP** and **stroke**
- Patients **observe goal-directed actions** (video or live demonstration)
- Then patients **imitate and perform** the observed movements
- Based on activation of the **mirror neuron system**
- Supports **motor learning and recovery** in affected limbs

Buccino G. et al. Action observation treatment improves upper limb motor functions in children with cerebral palsy: a combined clinical and brain imaging study, Neural Plasticity. (2018) 11.

INTERVENTION

Action Observation Therapy Group

30 min. Upper Extremity Bilateral Activity Training
+
30 min. Upper Extremity Action Observation Therapy

(3 days a week, 1 hour, 6 weeks. Total 18 sessions)

*Upper Extremity Bilateral Activity Training is conducted using activities determined by the COPM (3 activities per session)
*Upper Extremity Action Observation Therapy will consist of 3 stages. It is conducted using activities determined by the COPM (1 activity per session)
1) ROM
2) Reaching and Object Manipulation
3) Functional Tasks

Mirror Therapy Group

30 min. Upper Extremity Bilateral Activity Training
+
30 min. Upper Extremity Mirror Therapy

(3 days a week, 1 hour, 6 weeks. Total 18 sessions)

*Upper Extremity Bilateral Activity Training is conducted using activities determined by the COPM (3 activities per session)
*Upper Extremity Mirror Therapy will consist of 3 stages. It is conducted using activities determined by the COPM (2 activities per session)
1) ROM
2) Reaching and Object Manipulation
3) Functional Tasks

Statistical Analysis

- Normality assessed with Shapiro–Wilk test
- Mann–Whitney U: between-group comparisons
- Chi-square: categorical variables
- Friedman test: repeated measures
- Bonferroni post-hoc for pairwise comparisons
- Effect sizes calculated using Cohen's d

RESULTS

Table 1: Age, education and BMI information of the participants

	AOT (n=12)		MT (n=12)		z	p
	Mean±SD	Min-Max	Mean±SD	Min-Max		
Age (year)	8,33±1,49	6-11	8,58±1,67	6-11	-0,323	0,74
Education (year)	3,08±1,31	1-5	3,16±1,19	1-5	-0,208	0,83
BMI (kg/m²)	19,66±1,43	18-22	20,16±1,46	18-23	-0,826	0,40

*AOT: Action Observation Therapy, MT: Mirror Therapy, SD: standard deviation, BMI: body mass index.

The demographic characteristics of children in both groups were similar.

Table 2: Information on categorical data of participants

		AOT (n=12)	MT (n=12)		
		n (%)	n (%)	x²	p
Gender	Girl	6 (50)	7 (58,33)	0,168	0,68
	Boy	6 (50)	5 (41,66)		
Affected Extremity	Right	7 (58,33)	6 (50)	0,168	0,68
	Left	5 (41,66)	6 (50)		
MACS Level	I	7 (58,33)	8 (66,66)	0,400	0,81
	II	3 (25)	3 (25)		
	III	2 (16,66)	1 (8,33)		
GMFCS Level	I	9 (75)	10 (83,33)	0,253	0,61
	II	3 (25)	2 (16,66)		

*AOT: Action Observation Therapy, MT: Mirror Therapy, GMFCS: Gross Motor Function Classification System, MACS: Manual Ability Classification System.

Table 4: Within-group comparisons of pre-intervention, post-intervention, and 1-month follow-up assessments for COPM

AOT Group										
	Pre-Intervention (T0)		Post-Intervention (T1)		1 Month Follow-up (T2)					
	Mean±SD	Median (IQR)	Mean ±SD	Median (IQR)	Mean ±SD	Median (IQR)	p		p	d
COPM Performance (1-10)	4,93±1,30	4,9 (3,8)	6,38±1,08	6,6 (4,0)	6,30±1,11	6,4 (4,0)	<0,001**	T0-T1	<0,001**	0,72
								T0-T2	0,005*	0,69
								T1-T2	0,922	0,01
COPM Satisfaction (1-10)	5,06±1,40	5,0 (4,2)	6,65±1,32	6,8 (4,2)	6,51±1,23	6,6 (3,8)	<0,001**	T0-T1	<0,001**	0,82
								T0-T2	0,007*	0,80
								T1-T2	0,662	0,01
MT Group										
	Pre-Intervention (T0)		Post-Intervention (T1)		1 Month Follow-up (T2)					
	Mean ±SD	Median (IQR)	Mean ±SD	Median (IQR)	Mean ±SD	Median (IQR)	p		p	d
COPM Performance (1-10)	4,78±1,28	4,6 (4,4)	7,13±0,75	7,0 (2,2)	6,98±0,83	6,8 (2,2)	<0,001**	T0-T1	<0,001**	0,89
								T0-T2	0,005*	0,88
								T1-T2	0,922	0,02
COPM Satisfaction (1-10)	4,78±1,49	5,4 (5,0)	7,53±0,78	7,5 (2,8)	7,46±0,76	7,4 (2,6)	<0,001**	T0-T1	<0,001**	0,68
								T0-T2	0,002*	0,66
								T1-T2	1,000	0,02

*AOT: Action Observation Therapy, MT: Mirror Therapy, COPM: Canadian Occupational Performance Measure.

When the COPM results were examined by comparing the pre-intervention, post-intervention assessments between the groups, both groups showed an increase in both performance and satisfaction scores, and the results were similar.

Table 5: Within-group comparisons of pre-intervention, post-intervention, and 1-month follow-up assessments for GAS

AOT Group										
	Pre-Intervention (T0)		Post-Intervention (T1)		1 Month Follow-up (T2)					
	Mean±SD	Median (IQR)	Mean ±SD	Median (IQR)	Mean ±SD	Median (IQR)	p		p	d
GAS (-2 - +2)	-2,00±0,00	-2,0 (0,0)	-0,01±0,32	-0,1 (1,0)	-0,06±0,35	-0,2 (1,0)	<0,001**	T0-T1	<0,001**	0,72
								T0-T2	0,002*	0,68
								T1-T2	1,000	0,04
MT Group										
	Pre-Intervention (T0)		Post-Intervention (T1)		1 Month Follow-up (T2)					
	Mean ±SD	Median (IQR)	Mean ±SD	Median (IQR)	Mean ±SD	Median (IQR)	p		p	d
GAS (-2 - +2)	-2,00±0,00	-2,0 (0,0)	0,08±0,30	0,2 (0,8)	0,03±0,33	0,1 (1,2)	<0,001**	T0-T1	<0,001**	0,88
								T0-T2	0,002*	0,88
								T1-T2	1,000	0,02

*AOT: Action Observation Therapy, MT: Mirror Therapy, GAS: Goal Attainment Scale.

When comparing GAS results between groups, both groups showed an increase in scores, and the results were similar.

Table 6: Within-group comparisons of pre-intervention, post-intervention, and 1-month follow-up assessments for SHUEE.

AOT Group										
	Pre-Intervention (T0)		Post-Intervention (T1)		1 Month Follow-up (T2)					
	Mean±SD	Median (IQR)	Mean ±SD	Median (IQR)	Mean ±SD	Median (IQR)	p		p	d
SHUEE SFA (1-45)	20,33±5,95	21,5 (17,0)	28,58±5,29	29,5 (14,0)	28,25±5,20	28,5 (14,0)	<0,001**	T0-T1	<0,001**	0,68
								T0-T2	0,007*	0,66
								T1-T2	1,000	0,01
SHUEE DPA (1-72)	34,33±10,19	37,5 (26,0)	46,75±9,71	50,5 (27,0)	46,08±9,66	49,5 (26,0)	<0,001**	T0-T1	<0,001**	0,72
								T0-T2	0,009*	0,68
								T1-T2	0,459	0,01
SHUEE GR-RE (1-6)	2,16±1,11	2,5 (4,0)	3,66±1,23	3,5 (2,0)	3,50±1,38	3,0 (3,0)	<0,001**	T0-T1	<0,001**	0,68
								T0-T2	0,005*	0,66
								T1-T2	1,000	0,02
MT Group										
	Pre-Intervention (T0)		Post-Intervention (T1)		1 Month Follow-up (T2)					
	Mean ±SD	Median (IQR)	Mean ±SD	Median (IQR)	Mean ±SD	Median (IQR)	p		p	d
SHUEE SFA (1-45)	19,66±5,03	18,0 (14,0)	29,16±4,44	30,0 (13,0)	28,41±4,58	28,5 (12,0)	<0,001**	T0-T1	<0,001**	0,84
								T0-T2	0,003*	0,82
								T1-T2	1,000	0,02
SHUEE DPA (1-72)	31,25±7,82	28,0 (22,0)	46,08±7,91	46,5 (24,0)	44,25±6,92	45,0 (22,0)	<0,001**	T0-T1	<0,001**	0,89
								T0-T2	0,005*	0,88
								T1-T2	0,922	0,02
SHUEE GR-RE (1-6)	2,25±0,86	2,5 (2,0)	3,66±0,98	3,5 (3,0)	3,41±1,08	3,0 (3,0)	<0,001**	T0-T1	<0,001**	0,80
								T0-T2	0,002*	0,78
								T1-T2	1,000	0,02

*AOT: Action Observation Therapy, MT: Mirror Therapy, SHUEE: Shriners Hospital Upper Extremity Evaluation.

When comparing pre- and post-intervention assessments for SHUEE results between groups, both groups showed an increase in scores and the results were similar.

Table 7: Within-group comparisons of pre-intervention, post-intervention, and 1-month follow-up assessments for ABILHAND

AOT Group										
	Pre-Intervention (T0)		Post-Intervention (T1)		1 Month Follow-up (T2)					
	Mean±SD	Median (IQR)	Mean ±SD	Median (IQR)	Mean ±SD	Median (IQR)	p		p	d
ABILHAND (1-42)	20,41±6,08	22,5 (17,0)	27,66±6,03	30,0 (18,0)	26,91±5,82	28,5 (17,0)	<0,001**	T0-T1	<0,001**	0,90
								T0-T2	0,007*	0,88
								T1-T2	0,662	0,06
MT Group										
	Pre-Intervention (T0)		Post-Intervention (T1)		1 Month Follow-up (T2)					
	Mean ±SD	Median (IQR)	Mean ±SD	Median (IQR)	Mean ±SD	Median (IQR)	p		p	d
ABILHAND (1-42)	18,00±4,43	16,0 (12,0)	27,50±4,66	28,0 (15,0)	26,83±4,87	27,0 (17,0)	<0,001**	T0-T1	<0,001**	0,72
								T0-T2	0,003*	0,68
								T1-T2	1,000	0,02

*AOT: Action Observation Therapy, MT: Mirror Therapy.

When comparing pre- and post-intervention assessments for ABILHAND results between groups, both groups showed an increase in hand skills, and the results were similar.

Conclusion

- AOT and MT interventions resulted in significant improvements in occupational performance and satisfaction, achievement of activity goals, and upper extremity functional skills in children with unilateral CP. These improvements were sustained during a one-month follow-up period.
- The study results showed that the AOT group was more effective in terms of effect size for occupational satisfaction and bilateral upper extremity hand use skills; however, the MT group showed greater effect sizes in occupational performance, achievement of activity goals, and upper extremity functional skills.

Conclusion and Recommendations

- We recommend that occupational therapists working with children with unilateral CP include approaches such as AOT and MT in their intervention programs in addition to traditional OT intervention practices. This will be beneficial in improving intervention outcomes.
- Applying interventions to a homogeneous group of children with unilateral CP has allowed for clearer and more consistent interpretation of results.
- Future research is recommended on the duration, protocols, and individualization methods of applying these interventions to children with different types of CP.

THANK YOU

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