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Effect of Action Observation Training on Gross Motor Functions in Children with Spastic Cerebral Palsy

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ABSTRACT
Background: A non-progressive damage to the prenatal brain causes cerebral palsy (CP), a neuromuscular developmental condition. A permanent motor disability that impacts postural development and movement is the outcome. The most prevalent kind of CP that causes issues with posture and gait control is spastic diplegic CP.
Objective: The study was conducted to examine the impact of the action observation training (AOT) on gross motor functions (GMFs) in children with spastic diplegia. **Patients and Methods:** Thirty children aged from four to seven years diagnosed with spastic diplegia, were involved in this study. They were divided into two equal groups using random assignment. The participated children in both groups were given a designed physiotherapy program three times per week for two consecutive months. The study group was given the same physiotherapy program in addition to AOT. GMF of all children participating in both groups was assessed by gross motor function measure (GMFM) walking, running and jumping domain. **Results:** GMF improved significantly in both groups after treatment. When the results between the two groups were compared post-treatment, the results revealed a significant improvement in favor of the study group. **Conclusion:** This prospective study demonstrated beneficial effects of two months of physical therapy exercises combined with AOT on gross motor abilities in children with diplegia.
Keywords: Diplegia, Gait, Motor function, Action observation training.

INTRODUCTION

A chronic mobility and posture issue caused by non-progressive defects in the juvenile brain is known as CP [(1)]. The most prevalent kind of CP that causes issues with posture, balance, and gait control is spastic diplegia [(1)]. Spastic diplegia affects approximately 25% of CP patients and results from white matter periventricular injuries common in preterm infants [(2)]. It presents with hypertonia predominantly affecting the lower extremities, with upper limbs relatively spared. These children show abnormal gait patterns, for example, jump gait, equines gait and crouch gait [(3)].

Most children with spastic diplegia show noticeable abnormalities in their gait, yet they typically walk on their own. Sagittal plane deviations including toe walking, tight knees, flexed hips, and an anteriorly tilted pelvis with lumbar lordosis are examples of these problems. Many also walk more slowly than their counterparts, which results in higher energy consumption and decreased functional ability [(4)]. The time interval between any two ostensibly similar gait-process occurrences might be referred to as the gait cycle. Gait impairment is thus a common and debilitating consequence of childhood neurological disorders like CP [(5)]**.** Enhancing motor abilities by direct or indirect brain stimulation, including cognitive therapies, is the main goal of gait training programs. Cognitive rehabilitation training techniques that use motor and sensory nerve stimulation are one way to trigger brain plasticity [(6)].

One of the newly researched rehabilitation programs that enhances functional motions by activating the brain cortex's nerve cells is AOT [(7)]. A cognitive intervention strategy, AOT helps athletes, the general public, and individuals with motor impairments acquire and improve their exercise skills [(8)]. By encoding into the mental representation of the memory to arrange the planned action, motor-related information may be made available through visual function in AOT [(9)]. The AOT provides an opportunity to perform high repetitions of purposeful actions without muscle fatigue. Combining the observation with intent to imitate may further boost learning compared to passive viewing [(10)]**.**

Few research have used AOT to enhance upper extremity function in children with CP, despite the fact that several studies have been done on AOT in senior individuals [(11-13)]. Accordingly, there is no literature available that has examined the impact of AO on gait in children with CP. Therefore, this study was carried out to examine the efficacy of AOT in improving gait in children with CP by observing and imitating the normal gait cycle after dividing it into small tasks.

PATIENTS AND METHODS

This prospective randomized clinical trial was carried out at the 46 Center in El-Asher of Ramadan City from February 2022 to March 2023.

Children of both genders with spastic diplegic CP aged four to seven years were eligible to participate. Children were involved in the study if they had (1) spasticity ranging from grade 1 up to grade 2 according to the Modified Ashworth Scale, (2) performance level I or II according to the GMF Classification System, and (3) the ability to recognize and follow verbal assessments and treatment instructions. Children with visual or hearing impairments, lower extremity structural or fixed soft tissue malformations, cognitive impairments, or a history of lower extremity fractures, surgeries, or Botox injections within the preceding six months were not allowed to participate in the study. Sample size was determined using [G. Power, version 3.0.11] for Microsoft Windows, the sample size was at least 15 children in each group.

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Forty-three diplegic children with CP were evaluated for eligibility in the current research. Six of them chose not to participate, while seven were eliminated for not meeting the inclusion requirements. The remaining thirty kids were split up into 2 groups: Study group (A) and control group (B), as shown in figure (1).

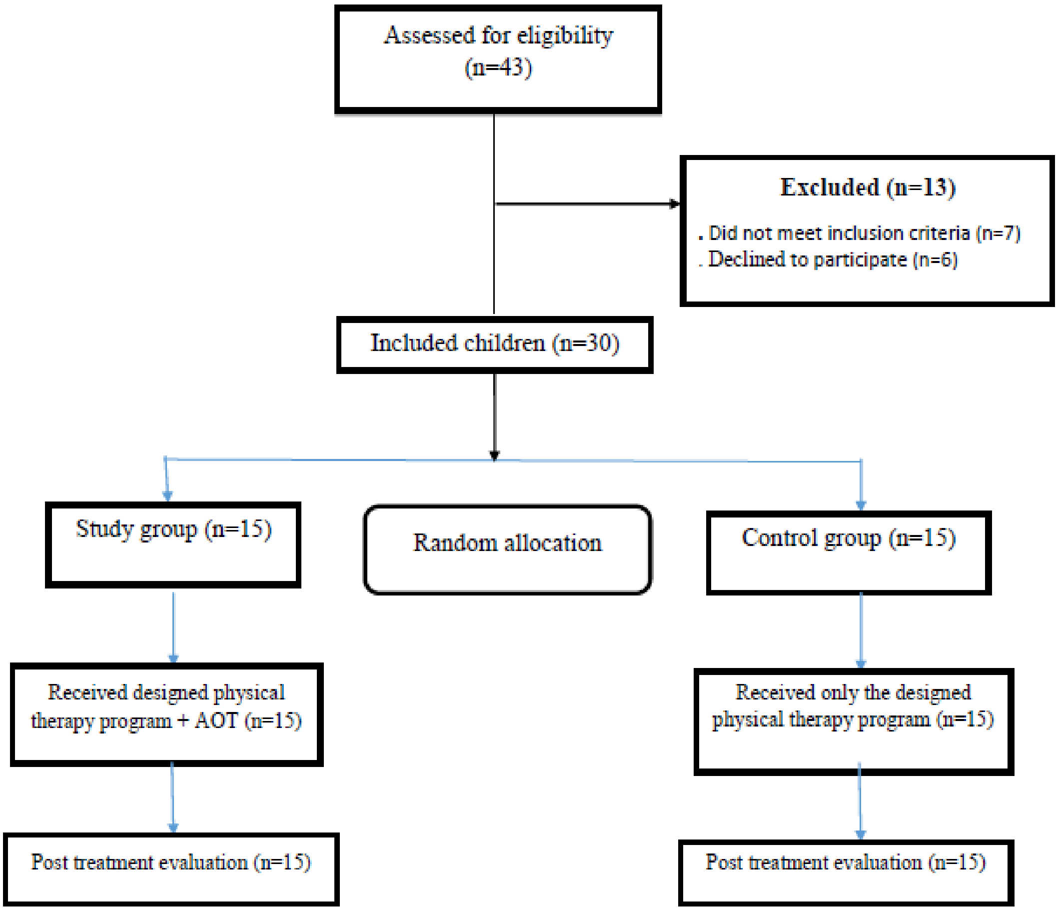

Figure (1): Participants flowchart.

Procedures:

All children were assessed using the GMFM-88 scale. The GMFM scale has been validated to assess change in motor performance in children with CP. In this study we assessed the items of walking, running and jumping of the GMFM. The items are scored on four-point ordinal scales (0=cannot initiate; 1=initiates; 2=partially completes item; 3=completes item independently) **[14]**.

According to **Eek and colleagues** **[15]** all participated children received the designed physiotherapy program included the following exercises: 1) Strengthening exercises for abdominal muscles, back muscles, hip extensors and quadriceps, 2) Bridging exercise, 3) Static and dynamic balance from sitting, kneeling and standing positions including the following steps, 4) Standing on one limb, 5) Stoop and recovery exercise, 6) Getting up to stand from supine and sit to stand, 7) Standing on balance board and tilting it antero-posterior and medio-lateral, 8) Gait training in closed environment using stepper, hand rails, obstacles, 9) Single-leg standing.

The control group consisted of fifteen children with spastic diplegic CP who received a specially tailored physiotherapy program for 45 minutes each session, 3 times a week, for two months. The study group got the same specified physical therapy program, as well as AOT for 30 minutes per session, three times a week for two months.

According to **Jeong and Lee** **[8]**, children with spastic diplegia sat comfortably and watched films on a 42-inch screen that was placed one meter in front of their seats. The movement exercise model in the video was performed by normal person, and the training videos consisted of 4 stages, each stage lasted 2 weeks and consisted of several subtasks. At a certain time, the kids watched the films in a noise-free, silent environment. They were told to spend a minute watching the video. Children were instructed to mimic the same subtask in the film in the same way after seeing the videos.

Action observation training protocol:

Stage 1: a) Stand with trunk and pelvis upright, b) Shift weight to the right and left, c) Rotate the trunk to the right and left by taking a ball from a table on the Rt. side and placing it on a table on Lt. side and vice versa. **Stage 2:** a) Walk sideways to the right, b) Walk sideways to the left, c) Step position standing on the right lower limb with the hip and knee of the left lower limb flexed, the ankle dorsiflexed and then descended to the heel strike and then returned to the original standing position. The same action was done with the right lower limb. **Stage 3:** a) Take a step with right lower limb, mid stance and initial swing of the left lower limb and return, b) Take a step with left lower limb, mid stance and initial swing of the right lower limb and return, c) Perform a full step with all phases of gait cycle, d) At the end of gait cycle, try to kick a ball. **Stage 4:** a) Walk on an inclined surface, b) Alternately ascend and descend the stairs.

Ethical approval:

The Ethical Committee of Cairo University's Faculty of Physical Therapy in Egypt gave its approval to the study (No. P.T.REC/012/003538). Before beginning the study procedures, the parents of each subject gave their informed consent. Throughout its implementation, the study complied with the Helsinki Declaration.

Statistical analysis

SPSS 25.0 for Windows was used to do the statistical analysis. The homogeneity of variance and normality assumption tests were performed on the data. Following the elimination of outliers identified by box and whisker plots, the data's non-normal distribution ($P<0.05$) was reflected by the Shapiro-Wilk test, which was used to test for data normality. Age, weight, height, and BMI are the general characteristics variables that were compared between the two groups using an independent t-test. The X^2-test was performed to compare the gender variable between the two groups. Results of GMFM across groups were compared using the Mann-Whitney U test, while data within groups wre compared using the Wilcoxon signed ranks test. Any p-value that was equal to or less than 0.05 was regarded as significant.

RESULTS

I-Subject characteristics:

There weren't significant differences between both groups in demographic data for children age, weight, height, BMI, and gender ($P>0.05$) as presented in table (1).

Table (1): General characteristics of both groups

Items	Groups		***P*-value**
	Study group (n=15)	**Control group (n=15)**	
Age (year)	5.73 ±1.10	5.85 ±1.14	0.778
Weight (kg)	21.38 ±3.26	21.52 ±2.89	0.904
Height (cm)	113.07 ±7.27	112.92 ±6.64	0.956
BMI (kg/m^2)	16.63 ±0.86	16.82 ±0.94	0.611
Gender (boys: girls)	11 (73.3%): 4 (26.7%)	9 (60.0%): 6 (40.0%)	0.439

Numerical data (age, weight, height, and BMI) are expressed as mean ±standard deviation and compared by independent-t test.
Categorical data (gender) are expressed as number (percentage) and compared by chi-square test.
P-value: probability value; $P>0.05$: non-significant

II-Within group comparison:

As presented in table (2), the study group showed significant improvements in all tasks of GMFM except two tasks (no. 3 and 4) showed non-significant improvement ($P>0.05$). On the contrary, the control group showed only improvement in four tasks (n. 7, 9, 10 and 23).

III-Between group comparisons:

When comparing the results between groups, there weren't significant differences between both groups before starting the rehabilitation program in all tasks. While the results revealed significant improvement in the total score of walking domain post treatment. Seven tasks showed non-significant differences after treatment between both groups as illustrated in table (2).

Table (2): Inter-group and intra-group comparisons for GMFM variable

Tasks	Items	Study group	Control group	*P*-value
1: STD, 2 hands on large bench: cruises 5 steps to R	Before-treatment	2.60 ±0.50	2.53 ±0.25	1.000
	After-treatment	3.00 ±0.00	2.65 ±0.30	0.034*
	Improvement %	15.38%	4.74%	
	P- value	0.014*	0.317	
2: STD, 2 hands on large bench: cruises 5 steps to L	Before-treatment	2.59 ±0.50	2.72 ±0.21	0.317
	After-treatment	3.00 ±0.25	2.79 ±0.28	0.007*
	Improvement %	15.83%	2.57%	
	P- value	0.025*	1.000	
3: STD, 2 hands held: walks forward 10 steps	Before-treatment	3.00 ±0.00	3.00 ±0.00	1.000
	After-treatment	3.00 ±0.00	3.00 ±0.00	1.000
	Improvement %	0.00%	0.00%	
	P- value	1.000	1.000	
4: STD, 1 hand held: walks forward 10 steps	Before-treatment	2.87 ±0.35	3.00 ±0.00	0.150
	After-treatment	3.00 ±0.00	3.00 ±0.00	1.000
	Improvement %	4.53%	0.00%	
	P- value	0.157	1.000	
5: STD, walks forward 10 steps	Before-treatment	2.60 ±0.63	2.57 ±0.29	0.315
	After-treatment	2.98 ±0.25	2.63 ±0.32	0.004*
	Improvement %	14.62%	2.33%	
	P- value	0.025*	0.557	
6: STD, walks forward 10 steps, stops, turns 180, returns	Before-treatment	2.40 ±0.63	1.93 ±0.79	0.093
	After-treatment	4.53 ±7.62	2.73 ±0.59	0.0001*
	Improvement %	88.75%	41.45%	
	P- value	0.001*	0.059	
7: STD, walks backward 10 steps	Before-treatment	1.60 ±0.82	1.73 ±0.59	0.448
	After-treatment	2.40 ±0.63	2.20 ±0.56	0.009*
	Improvement %	50.00%	27.17%	
	P- value	0.003*	0.008*	
8: STD, walks forward 10 steps carrying a large object with 2 hands	Before-treatment	2.00 ±0.65	2.07±0.38	0.401
	After-treatment	2.60 ±0.50	2.11 ±0.14	0.001*
	Improvement %	30.00%	1.93%	
	P- value	0.003*	0.380	
9: STD, walks forward 10 consecutive steps between parallel lines 20 cm apart	Before-treatment	2.13 ±0.64	2.40 ±0.63	0.246
	After-treatment	2.53 ±0.51	2.80 ±0.41	0.128
	Improvement %	18.78%	16.67%	
	P- value	0.014*	0.034*	
10: STD, walks forward 10 consecutive steps on a straight line 2 cm wide	Before-treatment	1.40 ±0.63	1.33 ±0.48	0.900
	After-treatment	2.13 ±0.35	1.60 ±0.50	0.004*
	Improvement %	52.14%	20.30%	
	P- value	0.001*	0.046*	
11: STD, steps over stick at knee level R foot leading	Before-treatment	1.47 ±0.91	1.67 ±0.72	0.548
	After-treatment	2.00 ±0.65	1.73 ±0.70	0.271
	Improvement %	36.05%	3.59%	
	P- value	0.011*	0.564	
12: STD, steps over stick at knee level L foot leading	Before-treatment	1.33 ±0.61	1.47 ±0.91	0.578
	After-treatment	2.20 ±0.56	1.67 ±0.72	0.032*
	Improvement %	65.41%	13.61%	
	P- value	0.002*	0.180	
13: STD, runs 4.5m (15), stops& returns	Before-treatment	1.87 ±0.74	2.07 ±0.55	0.443
	After-treatment	2.93 ±0.61	2.13 ±0.28	0.0001*
	Improvement %	24.60%	2.90%	
	P- value	0.020*	0.357	

Tasks	Items	Study group	Control group	*P*-value
14: STD, kick ball with R foot	Before-treatment	2.27 ±0.45	2.13 ±0.51	0.484
	After-treatment	2.80 ±0.41	2.27 ±0.59	0.010*
	Improvement %	23.35%	6.57%	
	P- value	0.005*	0.317	
15: STD, kick ball with L foot	Before-treatment	2.07 ±0.45	1.87 ±0.74	0.358
	After-treatment	2.93 ±0.25	2.07 ±0.70	0.0001*
	Improvement %	41.55%	10.70%	
	P- value	0.001*	0.083	
16: STD, Jumps 30cm high, both feet simultaneously	Before-treatment	1.47 ±0.64	1.47 ±0.74	0.891
	After-treatment	1.93 ±0.45	1.53 ±0.27	0.005*
	Improvement %	31.29%	4.08%	
	P- value	0.008*	0.502	
17: STD, Jumps forward 30cm, both feet simultaneously	Before-treatment	1.67 ±0.90	1.53 ±0.83	0.791
	After-treatment	2.07 ±0.70	1.53 ±0.74	0.001*
	Improvement %	23.95%	0.00%	
	P- value	0.014*	1.000	
18: STD, on R foot: hops on R foot 10 times within a 60cm circle	Before-treatment	0.73 ±0.04	1.00 ±0.75	0.185
	After-treatment	1.37 ±0.57	1.01 ±0.77	0.006*
	Improvement %	87.67%	1.00%	
	P- value	0.001*	0.681	
19: STD, on L foot: hops on L foot 10 times within a 60cm circle	Before-treatment	0.80 ±0.28	1.00 ±0.65	0.108
	After-treatment	1.40 ±0.73	1.13 ±0.74	0.401
	Improvement %	75.00%	13.00%	
	P- value	0.001*	0.157	
20: STD, holding 1 rail: walks up 4 steps, holding 1 rail alternating feet	Before-treatment	2.07 ±0.59	2.07 ±0.79	0.946
	After-treatment	2.47 ±0.64	2.13 ±0.74	0.204
	Improvement %	19.32%	2.90%	
	P- value	0.014*	0.317	
21: STD, holding 1 rail: walks down 4 steps, holding 1 rail alternating feet	Before-treatment	2.60 ±0.50	2.20 ±0.94	0.266
	After-treatment	2.87 ±0.35	2.33 ±0.81	0.020*
	Improvement %	10.38%	5.91%	
	P- value	0.046*	0.157	
22: STD, walks up 4 steps alternating feet	Before-treatment	1.93 ±0.59	1.87 ±0.91	0.722
	After-treatment	2.60 ±0.63	1.87 ±0.91	0.024*
	Improvement %	34.72%	0.00%	
	P- value	0.004*	1.000	
23: STD, walks down 4 steps alternating feet	Before-treatment	1.07 ±0.70	1.20 ±0.86	0.719
	After-treatment	1.93 ±0.79	1.47 ±0.74	0.003*
	Improvement %	80.37%	22.50%	
	P- value	0.006*	0.046*	
24: STD, on 15cm step: jumps off, both feet simultaneously	Before-treatment	1.73 ±0.96	1.27 ±0.79	0.125
	After-treatment	2.00 ±0.75	1.40 ±0.82	0.060
	Improvement %	15.61%	10.24%	
	P- value	0.046*	0.157	
Total score	Before-treatment	45.13 ±7.35	47.33 ±8.49	0.328
	After-treatment	58.27 ±6.14	51.87 ±7.75	0.023*
	Improvement %	29.12%	9.59%	
	P- value	0.001*	0.001*	
Percent	Before-treatment	62.30 ±10.37	65.73 ±11.79	0.289
	After-treatment	80.92 ±8.52	72.00 ±10.70	0.023*
	Improvement %	29.88%	9.53%	
	P- value	0.001*	0.001*	

Data are expressed as mean ±standard deviation ; P-value: probability value; * Significant (P<0.05)

DISCUSSION

In our investigation, the sample's age ranged from 4 to 7 years as this age is a critical time for intervention in children with spastic diplegia. A previous investigation detected that children with diplegic CP who received intensive therapy between the ages of 4 and 7 were more likely to walk independently than those who received therapy at a younger or older age. Our results are supported by **Samsir *et al.*** [16] who found that the children who received therapy at this age had better balance and coordination.

Based on the findings of this investigation, there was significant increase in the total score of of GMFM walking domain and also in all subtasks after-ttt compared to before-ttt within study group except task-3, and task-4 which recorded non-significant difference because children scored 3, which is the highest score in GMFM. These results come in accordance **Jeong and Lee** [8]**,** who found significant improvement of using AOT on the GMF, balance, and spasticity in children with CP. They claimed that, AOT can be used as an intervention to reduce the spasticity of ankle joint and to improve GMF and balance abilities of children with CP.

Also, our results are supported by **Park and Hwangbo** [17] who examined the impact of AOT on stroke patients' walking skills and static balance, and found that it had a favorable effect. They came to the conclusion that AOT is regarded as a therapeutically useful technique as stroke patients who are motivated to rehabilitate may readily adopt it. In addition, **Rojasavastera *et al.*** [11] reported that in older adults with modest cognitive impairment, AOT in conjunction with gait training improved overall cognitive performance and enhanced gait speed.

Regarding the control group, there were significant differences in some tasks including walking forward, backward and down steps, and the GMFM total score as well. This significant improvement may be due to the effect of traditional physical therapy program for 2 successful months. This outcome is consistent with the findings of **Eek and colleagues** [15] who employed eight weeks of specially planned training with an emphasis on muscular strength, which improved gait function in children with CP in addition to increasing muscle strength.

The current study's findings led to the conclusion that the AOT combined with the designed physiotherapy program was more effective in enhancing children’s GMF in form of walking, running and jumping activities than using only the designed physical therapy program. Through encoding into the mental representation of the memory to arrange the planned action, motor related information may be made available through the visual function in AOT [9]. This concept can explain the significant improvement in GMF of the children in study group who received both traditional physical therapy and AOT.

The primary constraint of the current investigation was that several parents declined to have their children participate in the investigation, which extended the duration of the investigation.

CONCLUSION

The application of AOT may promote the functional independence of children with CP. Pediatric physical therapy clinics may incorporate the use of the AOT into their rehabilitation program because it is an efficient, applicable, and non-invasive approach for rehabilitation.

Conflict of interest: None.
Financial disclosures: None.

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