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Effect of Action Observation Physical Training on Quality of Upper Limb and Functional Independence in Children with Hemiplegia

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ABSTRACT

Purpose: The reason for doing this study was to see how action-observation physical training affected the quality of upper limb functions and functional independence among children who have hemiplegic cerebral palsy (HCP).

Subjects and Methods: Thirty children who have a diagnosis of HCP, aged 6-9 years, have been randomized into 2 groups: the control group got a routinely chosen physiotherapy program, whereas the examined group got action observation physical training (AOPT) on the upper limb besides a standard selected physiotherapy program for three successive months. Children who have cerebral palsy (CP) underwent the Quality of Upper Extremity Skills Test (QUEST) in order to determine the level of quality of their upper limbs' functions, including their movement patterns and hand functions, while the Wee Functional Independence Measure (Wee FIM) was utilized to assess their functional independence.

Results: According to statistical analysis, there had been no substantial variance between the two groups prior to therapy. After treatment, the examined group's four QUEST domains (dissociated movement, weight-bearing, grasp, and protective reaction) and WEE FIM significantly improved (P = 0.0001) when contrasted with the control group.

Conclusions: The addition of action observation physical training to physical therapy resulted in better, more effective and significant results on upper limb functional abilities in HCP children.

Keywords: Action observation physical training, Upper limb functional abilities, Hemiplegia, Cerebral palsy.

INTRODUCTION

A non-progressive disruption that occurs in the growing fetus or infant brain is what is known as CP, a collection of mobility as well as posture deviation that result in activity restrictions [(1)]. CP motor disorders frequently come along with disturbances in sensory, communication, cognition, perception, behavior, and seizures [(2)].

There are 1.5 to 3 cases of CP for every 1000 live births [(3)]. It's probable that low-income countries have more cases of CP compared to high-income ones [(4)]. Hemiplegic children use their hands for everyday activities; they face numerous practical obstacles [(5)]. Impaired hand functions are one of the most disabling symptoms in children with HCP who, in comparison to their other hand, use their afflicted hand less frequently and with lower quality [(6)].

Action observation physical training entails observing actions and repeatedly practicing those actions through imitation [(7)]. This training, which has been developed to effectively induce neuroplasticity by magnifying the impact of task-oriented training, is closely associated with imitation and observational learning [(8)].

In rehabilitation, positive benefits may be predicted by letting the patient imagine motions through a combination of action observation and imitation of action, followed by doing motions in line with the imagination [(9)].

Therefore, considering training via imitation and observational learning as rehabilitation training approaches may effectively induce improvements in motor abilities [(10)].

To the knowledge of the authors, no prior research has investigated the consequence of AOPT on upper limb functional abilities in HCP children. Thus, the focus of this research was to learn more about how AOPT affected children with HCP's quality of upper limb functions and functional independence. We hypothesized that there is no effect of AOPT on the quality of upper extremity functions and functional independence in HCP children.

SUBJECTS AND METHODS

The investigation is a prospective, controlled, randomised trial. It took place from August 2021 to July 2022.

Sample size: Sample size was determined with G*POWER (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany) statistical software, whose results demonstrated that fifteen participants per group would be required to conduct the study effectively. The calculation was performed utilizing α=0.05, power = 80%, and a large effect size of 1.1.

Participants: Thirty children of both genders were selected from Cairo University's Physical Therapy Faculty Outpatient Clinic. The inclusion criteria included spastic HCP; their age ranged from 6 to 9 years; their Manual Ability Classification System (MACS) was at level II or III; their degree of spasticity in the affected upper limb ranged between grade 1+ or 2 as per the Modified Ashworth Scale (MAS); their Gross Motor Function Classification System (GMFCS) has been at level II or III; and they were able to

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understand verbal commands given to them. Children were not allowed to participate if they suffered from auditory or visual problems, upper limb contractures or fixed deformities, any medicine that affects arousal and alertness status, epilepsy, or surgical procedures of the upper limb.

Randomization:

For inclusion in the current study, 34 children with HCP have been screened. Two children had not been included because they didn't match the criteria, and two children's parents did not want to take part in the study. Thirty children have been randomly split into 2 groups: the control group as well as the examined group, as shown in figure (1). The method of randomization was sealed envelopes; each envelope contained a sheet of paper that showed the child was either in the control or examined group. The randomization process had been performed by an independent individual who was blind to the study's protocol.

Ethics approval and consent to participate:

The research's protocol received approval from the Faculty of Physical Therapy's Ethical Committee at Cairo University (P.T.REC/012/003682) and Clinical Trails Registry (NCT05875012), Registered 24 May 2023, retrospectively registered, https://register.clinicaltrials.gov/. Before beginning this study, each parent who provided informed consent was given a thorough explanation of the study's protocol. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

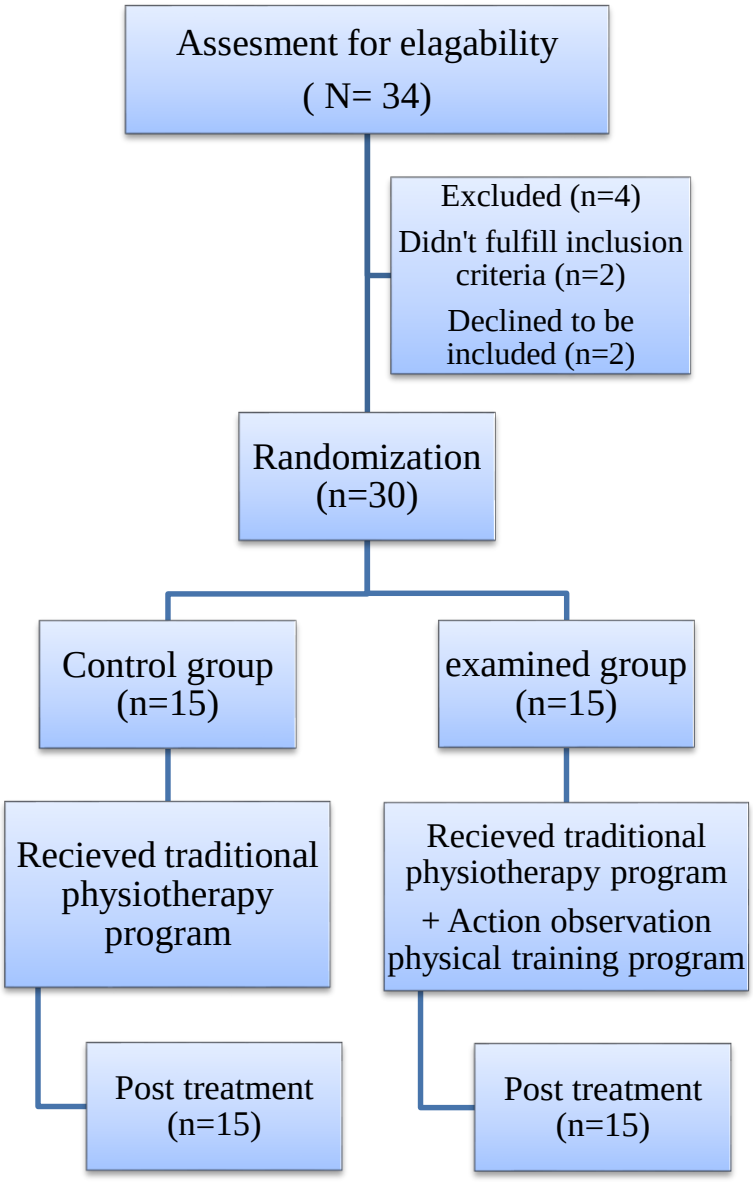

Figure (1): Flow chart of the study design

Testing procedures: The Manual Ability Classification System, which evaluates manual ability [(11)], MAS, which measures the increase of muscle tone [(12)], and GMFCS, which details the degree of gross motor function in youths and children suffering from CP [(13)], were used for subject selection in this study, while QUEST and Wee FIM were used for pre- and post-treatment assessment.

Evaluation of quality of upper limb functions (movement patterns and hand functions): The QUEST is a criterion-referenced outcome measure conducted to determine the quality of upper extremity functions (movement patterns and hand functions) in CP children. The QUEST is highly valid and reliable. This scale includes four domains with 33 items: dissociated movement (19 items), grasp (6 items), protective extension (3 items) and weight bearing (5 items) [(14)]. The four domains were assessed in this study.

Evaluation of functional independence: The Wee FIM is a modified version of the Functional Independence Measure Scale designed to assess the child's consistency in performance in everyday functional skills. The Wee FIM has 18 items that measure performance in 3 functional domains: self-care, mobility, and cognition [(15)]. The total score of the 3 functional domains was used while statistically analyzing our results.

Interventions: Control group: The control group had a standard, selected physiotherapy program consisting of three 0.5-hour sessions per week for three successive months (total therapy time: 1.5 hours/week). The standard selected physical therapy program involved: (1) Stretching exercises for wrist flexors and forearm pronators, (2) active free exercises for shoulder, forearm, and wrist, (3) strengthening exercises for spastic and antispastic muscle groups, (4) Hand weight-bearing exercises, (5) neurodevelopmental approach for inhibiting abnormal muscular tone and promoting normal postural control patterns**. Examined group:** The examined group got 0.5 hours of a standard, selected physical therapy program in addition to 0.5 hours of AOPT on the upper limb (total session time: 1 hour), 3 sessions per week for three consecutive months (total therapy time: 3 hours/week). Action observation was executed with therapist guidance and repeated practice (3 repetitions for each task). The child has been requested to perform the watched task with the same tool after observing a 3-minute video for each task on an adjustable monitor screen positioned one meter in front of him or her from forward, sideways, and backward directions. The therapist sat beside the child to provide verbal comments during the excursion and to guide the child's movement.

The AOPT for the examined group included six unimanual tasks and six bimanual tasks. The unimanual tasks included pressing a rubber stamp, stacking cups, drinking water from a cup, grabbing a pen, flipping cards, and putting things on a stick. The bimanual tasks were opening a bottle lid, punching holes in paper, folding a towel, opening a box, putting sweets in a box, and buttoning and unbuttoning. In each session, children have been requested to choose three tasks (two of the six bimanual tasks and one of the six unimanual tasks) [(16)]. The treatment was modified from **Kim [(16)]**.

Statistical analysis: The chi-squared test has been utilized to compare the distribution of spasticity grade, affected side, and sex between groups. GMFCS and MACS have been compared among groups employing the Mann-Whitney U test. Using the Shapiro-Wilk test, the data's normal distribution was examined. To test the variance homogeneity among groups, Levene's test was employed, and an unpaired t-test was utilized to contrast age, QUEST and Wee FIM among groups. In each group, a paired t-test was utilized to contrast pre and post treatment. The significance level for all statistical tests has been set at $p < 0.05$. The statistical analysis was carried out by SPSS version 25 for Windows (IBM SPSS, Chicago, IL, USA).

RESULTS

The participant characteristics of the control and the examined group were demonstrated in table 1. Age, GMFCS, MACS, sex, affected side, and spasticity grade distribution did not significantly differ across groups.

Table 1: Participants' basic characteristics

	Control group(N=15)	Examined group(N=15)	Statistics	p-value
Age (years), Mean ± SD	7.2 ± 0.92	7.46 ± 1.06	(t=-0.72)	0.46
GMFCS, median	2	2	(U = 112.5)	1
MACS, median	2	2	(U = 112.5)	1
Sex, n (%)				
Girls	10 (67%)	9 (60%)	(χ^2 = 0.14)	0.70
Boys	5 (33%)	6 (40%)		
Affected side, n (%)				
Right	3 (20%)	4 (27%)	(χ^2 = 0.19)	0.67
Left	12 (80%)	11 (73%)		
Spasticity grades, n (%)				
Grade I+	10 (67%)	10 (67%)	(χ^2 = 0)	1
Grade 2	5 (33%)	5 (33%)		

GMFCS, Gross motor classification system; MACS, Manual Ability Classification System; n, number; SD, standard deviation; t, unpaired t test; $\chi 2$, Chi squared value; U, Mann-Whitney U test

The examined group experienced a significant increase in all four QUEST domains after treatment in comparison with before treatment, while the control group had a substantial rise only in dissociated movement, weight-bearing, and total score following treatment in comparison with before treatment, with non-significant changes in grasp and protective extension. Proportional shift in the QUEST total score was 0.97% in the control group and 15.05% in the examined group.

Table 2: Mean QUEST before and after treatments for the control as well as examined groups

QUEST	Control group(N=15)	examined group(N=15)			
	Mean ± SD	**Mean ± SD**	**MD**	**t- value**	**p value**
Dissociated movement					
Pre-treatment	68.44 ± 4.77	70.13 ± 6.72	-1.69	-0.79	0.43
Post-treatment	70.15 ± 4.18	77.45 ± 5.16	-7.3	-4.25	0.001*
MD	-1.71	-7.32			
% of change	2.5	10.44			
t- value	-4.79	-6.31			
	p = 0.001*	***p = 0.001****			
Grasp					
Pre treatment	43.66 ± 2.5	43.18 ± 3.82	0.48	0.39	0.69
Post treatment	43.69± 2.46	68.33 ± 3.37	-24.64	-22.82	0.001*
MD	-0.03	-25.15			
% of change	0.07	58.24			
t- value	-1	-17.96			
	p = 0.33	***p = 0.001****			
Weight-bearing					
Pre-treatment	71.06 ± 1.66	71.46 ± 2.06	-0.4	-0.58	0.56
Post-treatment	71.6 ± 1.54	76.33 ± 2.05	-4.73	-7.11	0.001*
MD	-0.54	-4.87			
% of change	0.76	6.82			
t- value	-2.25	-6.39			
	p = 0.04*	***p = 0.001****			
Protective extension					
Pre-treatment	72.54 ± 0.99	73.1 ± 1.39	-0.56	-1.25	0.32
Post-treatment	72.97 ± 1.28	75.32 ± 2.23	-2.35	-3.53	0.001*
MD	-0.43	-2.22			
% of change	0.59	3.04			
t- value	-1.67	-3.57			
	p = 0.11	***p = 0.003****			
Total score					
Pre-treatment	63.93 ± 1.99	64.47 ± 2.49	-0.54	-0.65	0.51
Post-treatment	64.55 ± 1.83	74.17 ± 2.62	-9.62	-11.63	0.001*
MD	-0.62	-9.7			
% of change	0.97	15.05			
t- value	-5.11	-14.87			
	p = 0.001*	***p = 0.001****			

QUEST, quality of upper extremity skills test; MD, mean difference; *: significant

Both the control group and the examined group experienced a statistically substantial rise in Wee FIM after treatment in comparison with that prior to treatment. Before treatment, results did not considerably differ across groups. Following treatment, a comparison of the 2 groups revealed that the examined group exhibited a significantly greater dissociated movement, grasp, weight-bearing, protective extension, and total QUEST score than the control group. Wee FIM increased considerably in the examined group in comparison with the control group (Table 3).

Table 3: Mean Wee FIM before and after treatments for the control as well as examined groups

Wee FIM	Control group(N=15)	examined group(N=15)			
	Mean ± SD	Mean ± SD	MD	t- value	p value
Pre-treatment	94.13 ± 1.3	94.2 ± 1.37	-0.07	-0.13	0.89
Post-treatment	94.73 ± 1.57	104.2 ± 2.27	-9.47	-13.24	0.001 *
MD	-0.6	-10			
% of change	0.64	10.62			
t- value	-2.81	-15.11			
	p = 0.01*	***p = 0.001****			

Wee FIM, Wee functional independence measure; *, significant

DISCUSSION

The aim of this research has been to evaluate influence of AOPT on upper limb quality and functional independence in HCP children. Thirty children diagnosed with HCP, whose ages ranged from 6 to 9 years old, took part in this research. They have been split into two equal groups at random; the control group got a traditional physiotherapy program, while the examined group got a traditional physiotherapy program plus AOPT.

Before initiation of the treatment program, quality of upper limb and functional independence were conducted as a reference to compare post treatment values to detect the amount of improvement. The upper limb quality of movement for children included in this study was evaluated by using the QUEST, as a functional assessment tool. The selection of QUEST for assessment is supported by **Thorley *et al.*** who verified that QUEST is an effective tool for CP children aged from two to twelve years. The reliability of the total scores was high, and inter- as well as intra-rater reliability of the domains were both high [(17)]. The functional independence of the children involved in this study was evaluated using the WEE FIM. Rasch analysis was applied to verify WeeFIM's reliability and validity for children suffering from CP [(18)].

As a consequence of the findings of the most recent study, it appears that, improvement in quality of upper limb movement and functional independence in both groups and in the examined group's favor in contrast to the control group. Possible causes for this include AOPT depends on the recognized "mirror mechanism". AOPT used to refer to the motor-related stimulation of regions not just while an action is executed but additionally while the action is watched. This mechanism has been termed for the first time in the macaque's premotor cortex. There is currently consensus that there is a neural network made up of areas that exhibit the "mirror mechanism". The frontal lobe and the posterior parietal lobe are the most consistent areas. This brain network is known as the mirror neuron system (MNS) [(19)].

This study demonstrated that the examined group showed a substantial rise post-treatment in four domains of QUEST and WEE FIM in contrast to the control group. The post-treatment improvement of QUEST in this research is supported by the findings of a previous research by **Kim** that compared short- and long-term AOPT. The study enrolled ten children with CP. Both the examined group (n = 5) and the control group (n = 5) of children had been assigned at random. The study revealed that QUEST findings were enhanced significantly in two groups ($p < 0.05$) [(16)]. Also, when action observation (AO) and repeated practice (RP) are in comparison with RP alone in the treatment of the upper limbs of children suffering from unilateral CP, there has been a significant enhancement in favor of the combined group compared to RP alone [(20)].

Furthermore, the outcomes were consistent with prior research by **Kim *et al.*** which reported that grasp strength and WeeFIM scores were significantly improved at the three measurement time points (prior to, following, and 2 weeks after training completion) in the AOPT group in contrast to the physical training group [(7)] . In addition, the present research was supported by **Simon-Martinez *et al*.** [(21)] who revealed that adding AOPT resulted in bigger gains in children who had lower starting bimanual performance ($p=0.02$; $\eta 2=0.14$). For children who have poor motor function and a lot of mirror motions, the study concluded that adding AOPT to constraint-induced movement therapy (CIMT) improved outcomes.

According to **Sgandurra *et al.*** [(22)] children who have CP benefit more from AOT combined with execution than from execution alone. This research showed a substantial difference in hand functions among the experimental as well as control groups.

As well, **Buccino *et al*.** [(23)] aimed to assess the role of AOPT in the rehabilitation of upper extremity motor functions in 18 CP children aged from 5 to 11 years. The study revealed that, in comparison with controls, treated children exhibited a significant enhancement in upper extremity motor functions post-treatment, and this improvement persisted at 2 months of following-up.

Furthermore, **Kim *et al.*** [(24)] investigated how live and video AOPT affected the function and acceleration of upper limb movement in CP children. According to the findings of this study, live AOPT is more efficient compared to video AOPT in enhancing UL movement acceleration and function.

Limitations

While there are statistically significant differences in the objective data revealed by the present study, there are certain restrictions. To verify our findings, further comparative investigations utilising larger sample sizes

and a longer follow-up are required. Circumstances due to COVID-19 influenced the interaction with children and their parents. Caring responsibilities for children introduced additional considerations and stress.

CONCLUSIONS

It can be concluded from this study that the improvement in upper extremity function was considerably greater in the examined group than in the control group. So, the addition of AOPT to the traditional physical therapy program is advisable for improving the quality of upper extremity functions and functional independence in children with HCP.

DECLARATIONS

- **Consent for publication:** I attest that all authors have agreed to submit the work.
- **Availability of data and material:** Available.
- **Competing interests:** None
- **Funding:** No fund
- **Conflicts of interest:** no conflicts of interest.

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