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Research Article
Influence of Biofeedback and Task Oriented Training on Hand Skills in Children with Spastic Cerebral Palsy

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Abstract
Background and Objective: Impairment of hand function begins early in life has the potential to limit participation and causing distress to children and parents. The purpose of this study was to determine the effect of biofeedback training, task oriented training program and combination of both treatment on hand skills in children with spastic Cerebral Palsy (CP). **Materials and Methods:** Sixty six children with spastic cerebral palsy, ages ranged from 3-6 years were randomly divided into 3 groups of equal number: Children in group 1 received Task Oriented Training (TOT) program, group 2 received biofeedback training and group 3 received both in addition to traditional occupational therapy program for all groups. Treatment was conducted for 1 h and half, 3 times per week for a successive 3 months for all groups. Peabody Developmental Motor Scale (PDMS) was used to assess hand skills. Wrist extension angle was also measured using CorelDraw graphic suite X5 program. Modified Ashworth scale (MAS) and Gross Motor Functional Measure scale (GMFM) were used for sample selection. **Results:** Significant improvement in hand skills and wrist extension angle after treatment was gained in the 3 groups. Significant difference among 3 groups was obtained regarding fine motor quotient (FMQ), while no significant difference was gained regarding wrist extension angle after treatment between groups. **Conclusion:** It can be concluded that task oriented training or biofeedback training in conjunction with traditional occupational therapy significantly improved hand skills in children with spastic cerebral palsy.

Key words: Biofeedback, hand function, task oriented training, cerebral palsy, occupational therapy, wrist extension

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Hand function as an effector organ of the upper extremity for support, manipulation and prehension. The hand also may be used as a simple platform to transfer or accept forces. The most varied function of the hand is its ability to dynamically manipulate different objects[1]. Cerebral Palsy (CP) is a neuro-developmental condition caused by non-progressive lesion of the immature brain. This may occur before, during or up to 5 years after birth. It is the leading cause of childhood disability affecting function and development. Although CP is a primarily disorder of movement and posture, it often involves disorder of other developing functions such as sensation, perception, global and specific cognitive abilities[2]. The exact prevalence of CP is variable and depends on many factors. Today, studies has shown that, CP prevalence is around 2-2.5 per 1000 live births in both developed and developing countries[3].

Upper limb dysfunction is a common and disabling consequence of CP. Although brain lesions in children with CP are static, the movement disorders that arise are not unchanging. Common disorders of the arm and hand in CP include weakness and sensory impairment, spasticity and/or reduced muscle length associated with spasticity*,* dystonia or disuse. Various combinations of these impairments contribute to the difficulties experienced in reaching, pointing, grasping, releasing and manipulating objects[4]. Grasping and releasing require muscle balance between wrist flexors and extensors to grasp object with proper force of grasping not depending on spasticity and release with proper speed at accurate place. Cerebral palsied children with flexor spasticity and weak wrist extensors usually have poor grasping (sometimes grasp with aggressive maneuver) with difficult and slow release so balancing between both groups of muscles will help in improving hand skills. In recent years, increased evidence suggested that impairment-oriented therapeutic approaches may not be well founded and their efficacy is increasingly being questioned[5].

Biofeedback is a self-regulation technique through which patients learn to voluntary control what were once thought to be involuntary body processes. This intervention requires specialized equipment to convert physiological signals into meaningful visual and auditory cues, as well as a trained biofeedback practitioner to guide the therapy[6]. Task-oriented training (TOT) is consistent with modern principles of motor learning favoring specificity of training and involves practice of activities that are specific to the intended outcome as well as meaningful to the person. During the past decade, the use of task-oriented training as a rehabilitation strategy to improve motor function has gained increasing momentum[5]. Task oriented training is one therapeutic approach taken to enhance motor abilities in the upper extremities. This type of training associated with actual activities of daily living is effective for recovering motor ability[7]. It helps with functional organization by repeatedly training on activity tasks associated with daily living based on motor learning[8].

Improvement in mobility function has been the primary goal in the rehabilitation of children with cerebral palsy. Many of the traditional neurorehabilitation approaches designed to target mobility function focused on management of impairments. However, there is little evidence that intervention directed at the impairment level is effective for children with disabilities and improvements in impairments may not be generalized to function[5]. Rehabilitation methods based on the motor learning theory are characterized by repetitive practice of functional activities in various contexts which are accompanied by sufficient feedback[9]. This study was therefore designed to determine the effect of biofeedback training, task oriented training and combination of both treatment procedures on hand skills in children with spastic CP.

MATERIALS AND METHODS

Study design: This study was an experimental study that was performed at outpatient clinic of National Institute of Neuromotor System, Giza, Egypt. The collection of the data and applying the treatment for 3 groups start at March, 2017 and ended at January, 2018.

Subjects: About 66 children (of both sex) with spastic CP, with ages ranged from 3-6 years (mean age 50.98±7.751 months), participated in this study after their parents signed consent form for their children's participation. Children were included if they met the following criteria: (1) Wrist flexor spasticity ranged from 1+ to 2 grade according to modified Ashwarth scale[10], (2) Ability to sit alone or even with support and (3) Sufficient cognition to allow them to follow simple verbal commands and instructions during tests and training. Children were excluded if they had (1) Fixed contractures or deformities in the upper limb, (2) Botulinum toxin injection in the last 6 months before the study, (3) Previous surgical intervention in the upper limbs and (4) Visual or auditory defects.

Procedures

Evaluative procedure: Modified Ashwarth Scale (MAS) and Sitting domain of Gross Motor Function Measure (GMFM) were done as a pre-selective assessment scales to confirm the selection of the sample.

The Peabody Developmental Motor Scale and measuring wrist extension angle were done pre and post-treatment to follow the progress of the results:

- **Evaluation of spasticity:** Modified Ashworth scale (MAS)[10] was used to quantify the degree of spasticity in the wrist flexors. From grade 1+ to grade 2 was selected
- **Evaluation of sitting abilities:** Sitting domain of Gross Motor Function Measure (GMFM) was used to assess sitting abilities[11]. Children were who able to sit with self support and sit alone were selected
- **Evaluation of hand skills:** The Peabody Developmental Motor Scale (PDMS) was used to evaluate fine hand skills including grasping and visual motor integration subtests[12]. Each child sat on a chair-table. The table should be large enough to allow the examiner and the child to sit opposite to each other or side by side. All materials within the examiner's reach and out of the child view. Scoring of PDMS was from 0-2. The raw score converted to standard score for each sub-test and finally, the fine motor quotient was calculated
- **Evaluation of wrist extension angle:** Each child sat on a chair in front of table, with adducted shoulder, flexed elbow 90° and wrist extension. Three rounded disposable adhesive dots were placed to measure wrist extension angle as follow: (1) Same line below the ulnar styloid process, (2) The distal end of the ulna at the ulnar styloid process and (3) The base of the 5th metacarpal bone[13]. The child was asked to move his/her hand in extension and repeat that for three times while the trails were captured. Then the average range of wrist extension angle was been calculated using CorelDRAW graphic suite X5

Treatment procedure:

- **Group 1:** Children in this group received task oriented training (TOT) program for 30 min and traditional occupational therapy program for 1 h. Grasping, releasing, throwing and training for activities of daily living such as using cup, spoon, mobile, buttoning and unbuttoning, opening and closing zipper, removing garment and coloring shapes were applied[14]
- **Group 2:** Children in this group received biofeedback training for 30 min and traditional occupational therapy program for 1 h. Steps were explained to every child. The child sat in front of table, the area of treatment scrubbed with an alcohol pad, one pair of electrodes was being placed at the muscle bulk of wrist extensors. The child was asked to extend his wrist as much as possible to increase the signal on the monitor
- **Group 3:** Children in this group received task oriented training program, biofeedback training and traditional occupational therapy program. Gentle stretching for wrist flexor muscles, graduated active wrist extension and training for hand skills (as reach, grasp, push, carry or lift) objects were applied

Data analysis: All statistics were calculated by using the statistical package of social sciences (SPSS) version 23. Descriptive statistics (mean and standard deviation) of the children's ages, GMFM score, FMQ and wrist extension angle were conducted. Non-parametric tests (the Wilcoxon signed rank test and Chi square test) were used to analyze the pre and post-treatment values of MAS and FMQ within the groups. One-way ANOVA was used to compare the results of the study among groups pre and post-treatment for each variable. A p-value of less than 0.05 was taken as significant.

RESULTS

The results in Table 1 showed the demographic and clinical data of children in 3 groups. The mean values of age of children in group 1, 2 and 3 were 51.95±8.208, 49.86±7.748 and 51.14±7.498, respectively. The mean value of GMFM (sitting domain) of group 1, 2 and 3 were 33.91±5.389, 35.18±5.981 and 33.68±6.252, respectively. There was non-significant differences among 3 groups regarding age (p = 0.673), MAS (p = 0.784) and GMFM (p = 0.662).

Hand skills: The data in Table 2 revealed the comparison of FMQ values pre and post-treatment of each group using Wilcoxon signed rank test. It showed significant improvement of hand skills in the 3 groups (p<0.0000).

Data given in Table 3 demonstrated the results of comparing the FMQ value among 3 groups pre and post-treatment using one way ANOVA. It revealed non significant difference among 3 groups pre-treatment (p = 0.676) while it showed significant difference regarding FMQ post treatment (p = 0.029).

The Table 4 showed the results of multiple comparison between groups regarding FMQ. There was non-significant difference between group 1 and 2 (p = 1.000) and between group 2 and 3 (p = 0.218) while there was significant difference between group 1 and 3 (p = 0.028).

Table 1: Demographic and clinical data of the three groups

Parameters	G 1 (n = 22)	G 2 (n = 22)	G 3 (n = 22)	F	p-value
Age	51.95±8.208	49.86±7.748	51.14±7.498	0.399	0.673NS
MAS	(59.1%: 40.9%)	(50.0%: 50.0%)	(50.0%: 50.0%)	c2 = 0.487	0.784NS
GMFM	33.91±5.389	35.18±5.981	33.68±6.252	0.415	0.662NS

Data are expressed as Mean, NS: Not significant, c2: Chi-square test, G: Group, ±SD: Standard deviation, F: Analysis of variance, p-value: Probability value, MAS: Modified Ashworth scale, n: Number, GMFM: Gross motor functional measure

Table 2: Comparison of FMQ pre and post-treatment values for three groups

Groups	Pre (X±SD)	Post (X±SD)	Z-value	p-value	Sig
G 1	50.91±5.282	66.45±17.361	-4.116	0.000	Sig
G 2	50.23±5.606	69.45±7.385	-4.122	0.000	Sig
G 3	49.55±4.306	75.86±7.140	-4.124	0.000	Sig

X: Mean, ±SD: Standard deviation, Z-value: Wilcoxon signed rank test, p-value: Probability value

Table 3: Comparison of FMQ and wrist extension angle pre- and post-treatment values among groups

	Pre-treatment		Post-treatment	
Parameters	F	p-value	F	p-value
FMQ	0.394	0.676	3.747	0.029
Wrist angle	0.214	0.899	0.288	0.751

F: Analysis of variance, P-value: Probability value

Table 4: Multiple comparison of FMQ among groups

Groups	Mean difference	p-value	Significance
G 1 vs. G 2	- 3,ooo	1.000	NS
G 1 vs. G 3	- 9,409	0.028*	Sig
G 2 vs. G 3	- 6,409	0.218	NS

*The mean difference is significant at the 0.05 level

Table 5: Comparison of wrist extension angle pre and post-treatment values for three groups

Groups	Pre (X±SD)	Post (X±SD)	Z-value	p-value	Sig
G 1	7.09±5.698	33.82±11.790	-4.123	0.000	Sig
G 2	6.86±3.167	34.45±8.285	-4.117	0.000	Sig
G 3	6.64±2.517	35.95±8.232	-4.111	0.000	Sig

X: Mean, ±SD: Standard Deviation, Z-value: Wilcoxon signed rank test, p-value: Probability value

Wrist extension angle: Comparison of treatment values of wrist extension angle for each group using Wilcoxon signed rank test showed significant improvement in 3 groups (p<0.0000) as shown in Table 5. Comparing the results of wrist extension angle among the 3 groups using ANOVA test showed non-significant difference pre-treatment (p = 0.899) and also non-significant difference post-treatment (p = 0.751) among the 3 groups (Table 3).

DISCUSSION

The results of this study showed a significant improvement of all measuring variables (FMQ and wrist extension angle) in the 3 groups after 3 months of treatment. There was significant difference among three groups regarding FMQ, however non-significant difference was obtained regarding wrist extension angle after treatment among groups. The TOT program focused on the activities used in everyday which may be the cause of improvement in group 1 and 3. This comes in agreement with Ahl *et al.*[15] who reported that functional training significantly improved GMFM scores, ability to perform daily activities and decrease in caregiver assistance. Improvement of hand skills may be due to TOT program in addition to traditional occupational therapy program. This opinion is supported by Wu *et al.*[16] who concluded that, task oriented training improve motor performance, motor control strategies, sensory recovery and daily function more than the traditional treatment.

Functional training which was applied as apart of task oriented training may be the reason of improvement. This opinion is supported by Kalra[17] who stated movement performed in the presence of a functional task target (e.g., reaching forward to take a beverage) are smoother and faster than movements performed in the absence of such objects (e.g., reaching forward to a spot lacking a designated target) during seated reaching tasks. Improvement of children in group 2 may be attributed to biofeedback training and strengthening exercises. This result is supported by the opinion of Gordon *et al.*[18] who reported that to improve reaching motor function in children with CP, neuro-rehabilitation including neuro-developmental technique, constraint induced movement therapy, electromyography biofeedback and strength training are main techniques should be considered. The way of instructing and applying the exercises and training of hand skills in the current study which depending on motivation and encouragement as given during biofeedback training may be the cause of improvement gained in this study. This comes in agreement with Yoo *et al.*[19] who concluded that, biofeedback studies showed promising results to increase motor control since it allowed accurate visual feedback about motor recruitment of the involved arm or leg muscles in children with CP. Such meaningful improvements in motor function may stem from the fact that it provides a fun, motivating and functional exercises.

The focusing of training and the exercises on wrist extensors muscles in the current study as given during biofeedback training may be the cause of improvement gained in this study. This comes in agreement with Yoo *et al.*[19], that the efficacy of biofeedback intervention for enhancing the upper limb function of children with spastic CP. Improved muscle balance between the elbow flexor and extensor increases reaching motor performance in children with CP. Post-treatment improvement in the 3 groups may be due to application of TOT in motivational way and application of biofeedback training in a challenging way. This opinion comes in agreement with Salem and Godwin[5] who reported that one of the major challenges in the management of children with cerebral palsy is enhancing motivation to practice throughout the day. The motivation to participate in activities is closely linked to improvement in acquisition of motor abilities. Improvement of wrist extension angle in the 3 groups may be attributed to training exercise for wrist extensor muscles. This result comes in agreement with Salem and Godwin[5] who reported that a task-specific exercise program, focused on strengthening and functional performance, resulted in improved functional performance that was maintained over time in children with cerebral palsy.

Training of hand skills which was applied as a part of traditional occupational therapy program may be the reason of improvement. This opinion is supported by Wu *et al.*[20] who concluded that the use of real and functional objects might be an effective way of facilitating efficient, smooth and coordinated movement with the impaired arm. The relatively small sample size that limits the generalizability of the results of the study is the limitation of the current study to be considered.

CONCLUSION

The results of this study provided the evidence that the combination of task oriented training and/or biofeedback training with traditional occupational therapy can improve the hand skills and level of independence in children with spastic cerebral palsy.

SIGNIFICANCE STATEMENT

This study discovers the effectiveness of biofeedback training and task oriented training on hand skills that can be beneficial for children with spastic CP as challenging method of rehabilitation in combination with traditional occupational therapy. This study will provide the researcher with clinical protocols for further applications on similar cases or further research on different types of cases to solve the critical problems of child and parents regarding hand skills that many researchers were not able to explore. Thus a new combination of rehabilitation protocols may be arrived at.

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