Eye-Hand Coordination and Fine-Motor Performance in Hemiparetic Cerebral Palsied Children

Manal Salah El Dien Abd El Whahab
Department of Physical Therapy for Growth and Developmental Disorders in Children and its Surgery, Faculty of Physical Therapy, Cairo University.

ABSTRACT

Background and purpose: *Hand use is voluntary under the control of conscious mind and it is regulated by feed-back from sensory organs. The purpose of this study was to detect the effect of stimulation of eye-hand coordination using computer rehabilitation program (via visual and auditory feedback training) on fine motor skills performance in hemipretic cerebral palsied children.* ***Subjects:*** *Subjects participated in this study included 24 hemiparetic cerebral palsied children (14 girls and 10 boys) ranged in age between six and eight years ($\bar{X}$ ±SD 6.69±0.78). They were selected from outpatients clinic for Occupational Therapy, Faculty of Physical Therapy, Cairo University and they were assigned randomly into two groups of equal number (12 patients in each group).* ***Procedures:*** *Children were assessed before and after three months of treatment application by using hand grip dynamometer to detect hand grip strength and Peabody developmental Motor Scale for detecting fine motor quotient, and age equivalent for both grasping and visual motor integration. Control group (GI) received a specific treatment program aiming to improve hand manipulation skills, while study group (GII) received the same program in addition to training of eye-hand coordination through using attractive computer games introduced from "Discover on Screen" rehabilitation program. Patients in each group were given a physical therapy program for stretching and increasing range of motion of the affected upper extremity and improve the physical condition for each child.* ***Results:*** *the results showed a statistically insignificant difference between both groups before treatment application however, there was a statistically significant difference of all measured variables after three months of treatment application in favor to the study group.* ***Conclusion:*** *physical Therapy treatment programs should emphasis on attractive training of eye-hand coordination to gain better hand performance in hemiparetic cerebral palsied children.*

Key words: *Cerebral palsy, Eye-hand coordination, Fine motor performance.*

INTRODUCTION

Hand is the primary mean of interaction with physical environment through the dexterous grasp and manipulation of objects. In many cases of children with spastic cerebral palsy (CP) there is affection of fine-motor performance which may be due to several causes as spasticity, lack of training, soft tissues contractures, affection of visual-perceptual skills or lack of eye-hand coordination[15]. Vision plays a very important role in the ability to reach out for objects. It is the sense that provides information about the layout of the environment and when reaching for an object, it defines both the position and shape of the object. Seeing the environment gives an opportunity to anticipate upcoming events and plan movements in an anticipatory fashion[10].

Eye-hand coordination is the modeling of actions to the physical characteristics of objects, places and events, such as shaping of the hand to fit the size and orientation of an object, reaching the required distance and

direction for grasp, or timing a reach to grasp a moving object[2]. It is the ability of the visual system to coordinate the information received through the eyes to control, guide, and direct the hands in the accomplishment of a given task, such as handwriting or catching a ball. Hand-eye coordination uses the eyes to direct attention and the hands to execute a task[19].

Skillful use of the hand under visual guidance is important and integral part of the total function. The development of eye-hand coordination skills represents a major human achievement in the ability to interact effectively with the environment and clearly reflect the capacity of the central nervous system to receive process and translate visual and tactile input into efficient well-executed motor behaviors[21].

Eye-hand coordination dysfunctions affects the child's ability to use tools and release materials to one another, thus bilateral manipulative skills are affected to a greater degree than the child's basic prehension patterns indicate. The child with eye-hand coordination deficits may show problems with cutting, coloring, constructing with blocks or other construction toys, doing puzzles, using fasteners, and tying shoes[3,24].

Children with CP have disturbed hand function because primary or secondary lesions involve the sensorimotor cortex and corticospinal tract that are responsible for fine-motor control of finger and hand, both of which have great implication for precision grip and independent finger movements[17,20] thus, skilled independent finger movements don't develop typically in children with hemiplegia. During tasks that require fine manipulation such children often use several fingers and often show abnormal hand posturing as well as reduction in distal strength and dexterity[5,12].

So the purpose of this study was to detect the effect of stimulation of eye-hand coordination via computer attractive feed-back rehabilitation program on fine motor performance in spastic hemiplegic cerebral palsied children.

SUBJECTS AND PROCEDURES

Subjects

Twenty four spastic hemiparetic CP children were selected from the outpatient clinic of Occupational Therapy, Faculty of Physical Therapy, Cairo University their ages ranged from 6 to 8 years with mild degree of spasticity of the affected upper limb ranged between grades 1 and 1^+ according to modified Ashower's scale. They were able to sit alone and maintain sitting balance. They did not have any soft tissues contractures or tightness of the affected upper limb, and they had the ability to reach, grasp and release a pencil.

Patients were assigned randomly into two groups of equal number (twelve patients in each group), they represented the control (GI) and study (GII) groups respectively.

Instrumentations

A) For assessment:

- Hand held dynamometer: (A JAMAR base-line hydrolic hand dynamometer manufactured by Summons Preston Inc., Canada) was used for measuring hand grip strength in Kgm.
- Peabody Developmental Motor Scale: The PDMS fine motor scale was used to examine the age equivalent for both grasping and visual-motor integration and fine motor quotient which are skills that were specifically targeted for improvement. Each item is scored as 0 (the child makes no attempt), as 1 (the child makes some attempt), or as 2 (the child completes the item in the specified, age-appropriate manner).

B) For treatment

I) Computer Set: with the following requirements:

● Pentium 2 processor. ● Windows 98. ● 29 MB hard disk space. ● Sound Blaster. ● 16 Mega Bites (MB) rams. ● CD-rom drive. ● A computer mouse.

II) Discover on Screen Software: It is a designed computer rehabilitation program. It displays a keyboard on the screen with choices for entering text, talking phrases for multisensory learning, performing multitask duties. This software was copyright in 1997 by Don Johnston.

III) Puzzles with different shapes, cubes, rings, and balls with different colors.

IV) Table and chair with suitable height.

Procedures

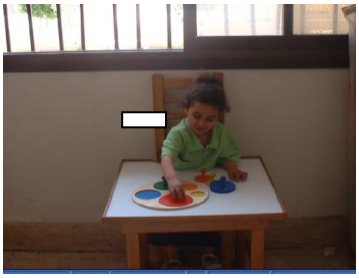
Evaluation procedures:

1- For hand grip strength: The child was asked to sit on a back-arm chair with back supported, shoulder extended and maintained beside the body with elbow flexed 90º and forearm and wrist in mid position[22] and to hold the dynamometer with the affected upper extremity. Each child was asked to hold the handle of the dynamometer and squeeze it with maximum strength, then release, readings were recorded in Kgm.

2- For fine motor development: Peabody was used for detecting age equivalent for both grasping and visual-motor integration and fine-motor quotient.

Treatment procedures for control group (GI):

Children in this group received a specific treatment program directed towards improving hand manipulation skills based on reaching, grasping, transferring objects with different sizes and shapes, building up towers with cubes and reconstructing different shapes of puzzles as illustrated in figures 1 a, b and c).



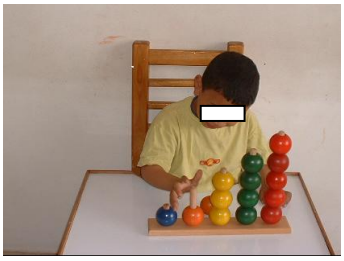


Fig. (1): a) Puzzle construction ***b) Transferring Cubes*** ***c) Arranging balls***

Treatment procedures for study group (GII):

Children in group II received the same exercises given to children in control group in addition to a specially designed computer rehabilitation program directed towards improving fine motor skills via controlled application of computer mouse movements (as a source of augmented feed-back) based on recognition, matching, and sorting. A series of simple games suitable for the corresponding age level were chosen, all of them were chosen on the base of the mouse movement as a primary mean of access and operation.

Each child in both groups received his/her physical therapy rehabilitation program aiming to improve the physical condition and they were treated three sessions per week for three successive months.

RESULTS

The effect of stimulation of eye-hand coordination via application of controlled computer mouse movements on fine-motor performance in spastic hemiparetic cerebral palsied children was investigated in this study. The raw data was collected and statistically analyzed using MiniTab statistical program for both groups before and after three months of treatment application to show the difference in mean values and significance of treatment procedures among both groups. No significant difference was observed when comparing the pre-treatment mean values of all measured parameters between both groups. However there was statistically significant difference of post-treatment mean values of all measured parameters among both groups after the suggested treatment period.

As shown in table (1) and illustrated in figures (2a, b and c) there was statistically insignificant difference between both control and study groups before treatment application regarding grip strength and standard scores for age equivalent for both grasping and visual-motor integration as well as for the fine-motor quotient.

Table (1): Mean values of grip strength, Age equivalent for grasping and visual-motor integration and Fine-motor quotient for both GI & GII before treatment.

	$\overline{X}$ ±SD GI	$\overline{X}$ ± SD GII	MD	t	P
Grip strength	1.68±0.8	1.54±0.64	0.10	0.35	>0.05
Age equivalent for grasping	4.83±1.52	4.66± 1.55	1.67	0.26	>0.05
Age equivalent for VMI	3.25±1.38	3.16±0.93	0.08	0.2	>0.05
Fine-motor quotient	63±4.9	63.83±4.71	0.83	0.42	>0.001

$\overline{X}$ ±SD: mean ± Standard deviation VMI: visual motor integration MD: Mean difference
P: probability value t: tabulated value

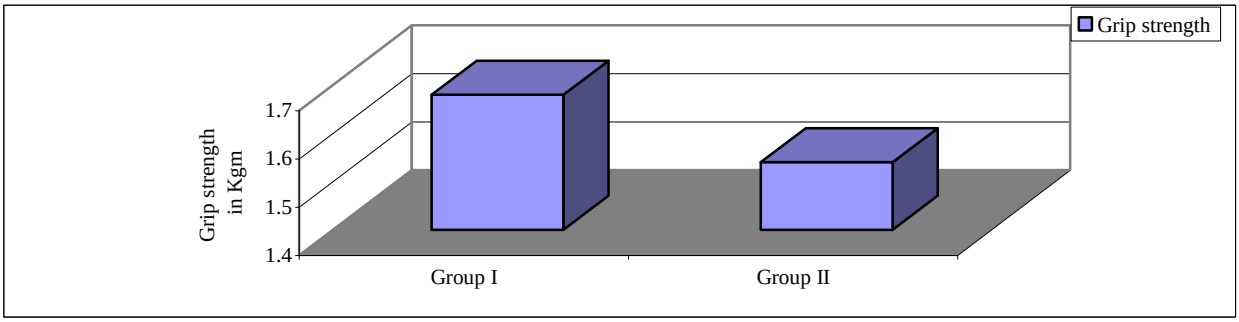


Fig. (2a): Mean values of hand grip strength (in Kgm) for both groups before treatment.

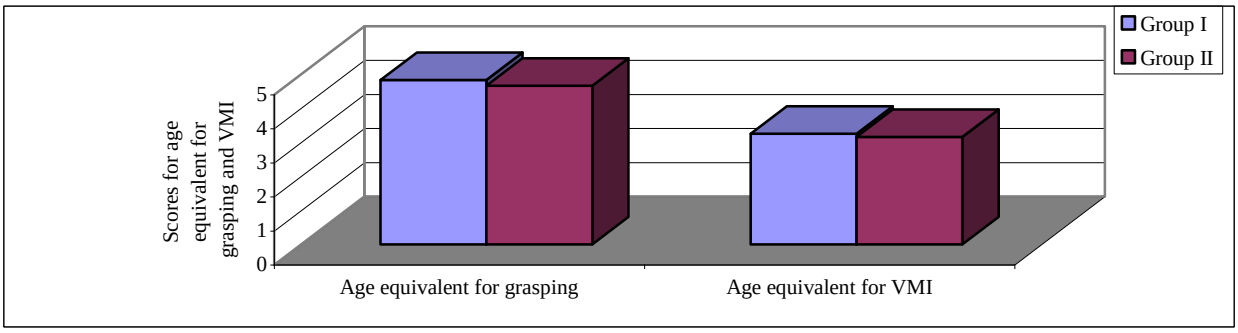


Fig. (2b): Mean values of both age equivalent for grasping and visual-motor integration among both groups before treatment.

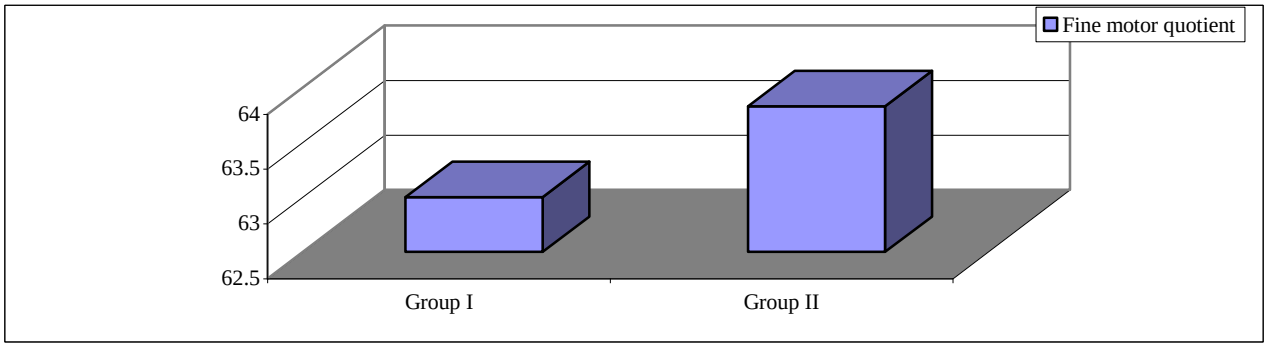


Fig. (2c): Mean value of fine motor quotient among both groups before treatment.

Table (2): Mean values of grip strength, Fine-motor quotient, Age equivalent for grasping and FMI between GI & GII after treatment.

	$\bar{X}$ ±SD GI	$\bar{X}$ ±SD GII	MD	t	P
Grip strength	2.39±0.84	4.29±0.68	1.54	4.92	<0.001
Age equivalent for grasping	6.16±1.64	7.91±1.37	1.75	2.88	<0.001
Age equivalent for VMI	4.66±1.07	5.75±1.35	1.08	2.17	<0.05
Fine-motor quotient	66.42±4.96	74.92±6.92	8.5	3.46	<0.001

$\bar{X}$ ±SD: mean ± Standard deviation VMI: visual motor integration MD: Mean difference
P: probability value t: tabulated value

This table illustrates that there was a statistically significant difference regarding grip strength, Fine-motor quotient, Age equivalent for grasping and Age equivalent for VMI among both groups GI & GII after treatment application.

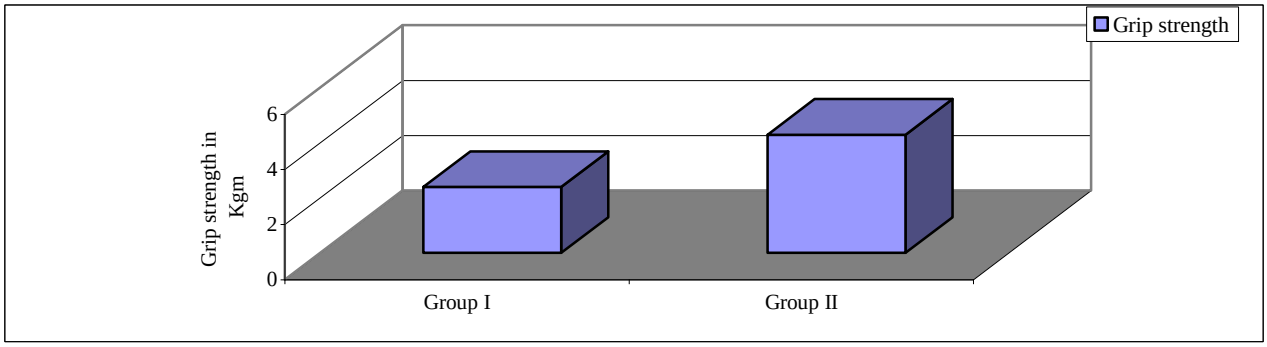


Fig. (3a): Mean values of grip strength between both control and study groups after treatment application.

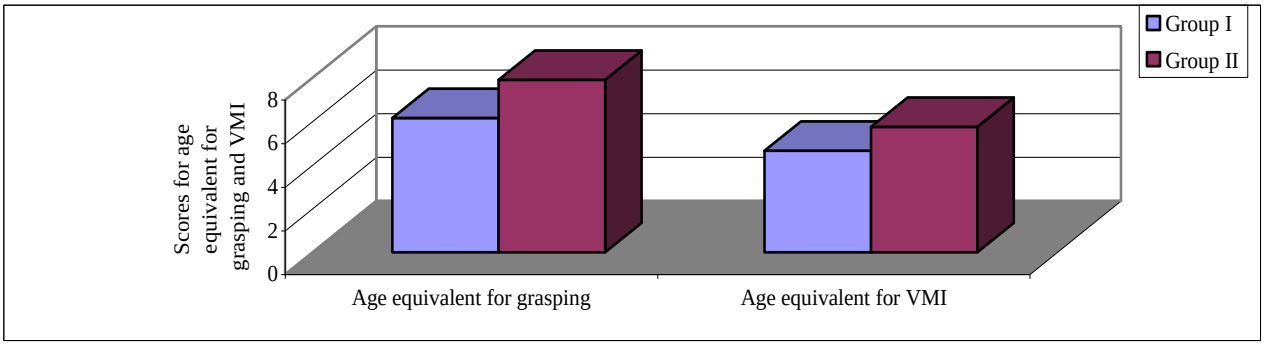


Fig. (3b): Mean values of both age equivalent for grasping and visual-motor integration among both groups after treatment.

Fig. (3c): Mean value of fine motor quotient among both groups after treatment.

DISCUSSION

This study was conducted to detect the effect of enhancement of eye-hand coordination through the use of controlled computer mouse movements on fine motor performance in spastic hemiparetic cerebral palsied children. The results showed that there was a statistically significant difference among both groups after treatment application. The difference may be attributed to increased attention of those children treated by using attractive designed computer games allowed by Discover on Screen software which may be considered a source of motivation for the child performance. Computer games had the ability to maintain the child's attention and increased duration of concentration.

The results of this study agree with the findings of Lewthwate[18], who investigated the research that had been performed on motivation and its relationship to the physical activity. She looked at the effects of personal, social and environmental motivation influences and found that strategies can be developed to benefit performance using effective motivational features.

The statistical significant difference between both groups can also be attributed to the effect of the used computer mouse movements as these movements placed the child's whole body especially head, trunk and the affected upper limb under non-observable stress. Mouse movements required steadiness of the head, postural balance at trunk level and stabilization at the level of the wrist and hand, repositioning of the upper limb and individual finger movement. These features placed the total body specially, upper limb in a complex category of movement without direct

instructions or continuous confusing orders given to the child to readjust and correct posture and hand position.

These results can be explained by the work of Anderson[1] who concluded that computer-based games put all players on equal ground, allowing disabled children to interact and compete in the playing environment with non-disabled peers and siblings. This assists in the development of social competencies, self-esteem and self-worth which, in turn foster personality development and maturation.

The results of this study can also be supported by Lane and Ziviani[26], who reported that the computer can be used as a motivational device to assist in increasing the child's attention to the task. They added that computer provides a way to practice skills in an independent manner. The therapist can adapt computer program by changing the pictures to those that enhance the child's visual-perceptual skills.

The results of this study also come in agreement with Hartveld and Hegarty[14]; who reported that feedback is an essential part on improving motor performance and learning. Computers may help to give better for movement therapy in order to provide immediate, frequent and attractive feedback to movement in a clinical setting and at home. They also reported that feedback is essential to motor learning and is therefore an important aspect of the treatment process for physiotherapists to consider as it could improve treatment outcomes.

The results of the current study also comes in agreement with previous studies[6,9] which reported that children with CP have an impaired development of grip and load force, that correlates with impairments in manual dexterity although most children with CP are capable of adjusting their grip forces to the object's weight and texture using sensory mechanisms, they typically have a decreased ability to scale the force output in advance (ie, anticipatory control) without extensive practice[4,7,8,11].

The statistical significant difference between both groups I and II can be attributed to the improvement in eye-hand coordination that had been reflected on fine motor skills performance, which indicates the close correlation between the fine-motor skills and eye-hand coordination skills. This comes in agreement with Warren[25] who reported that the repeated stimulation of eye-hand coordination will give the brain a chance for useful cycle between attention, concentration and visual-motor integration to be in a continuous use and there is a great correlation between both cognition and visual-motor skills that help the child to meet the requirements of daily living activities.

Using Peabody in this study comes in agreement with many authors[9,13] who reported that, fine motor skills, measured by using the Peabody Motor Developmental Scale, could still be learned despite an impaired motor pattern, especially at an early age for children with mild hemiplegic CP.

The results of this work contradict with Roberston[23], who reviewed the literature and concluded that cognitive retraining software did not produce any convincing evidence of the results facilitating enduring cognitive change. He added that the amount of time it took therapists to set up and use software could be employed more effectively in giving the patient direct training on the functional tasks. Facilitating enduring cognitive change. The only areas that documented positive results were those in attention and some language skills.

Using traditional line of treatment was useful but there was a facing problem that the child's line of interaction was gradually

decreased and his/her responses to common and familiar stimuli were reduced.

The results of the current study come in agreement with a habituation study of Hull[16] who found that the Infant's object manipulation decreased as a 30-minute session progressed, and that with increasing familiarization with a particular object the infant increased banging and dropping behaviors. Object manipulation skills were all accompanied by visual inspection, whereas the behaviors that occurred with habituation were without visual inspection.

Summery and conclusion

From the previous results we can conclude that attractive stimulation of eye-hand coordination through using controlled mouse movement on a specific rehabilitation programs can improve fine-motor abilities accuracy and precision in patients with spastic hemiplegic cerebral palsy.

REFERENCES

1- Anderson, R.A.: Visual and visual motor functions of the posterior parietal cortex. In P. Rakic and W. Singer (Eds.). Neurobiology of the neocortex. London: John Wiley & Sons. 1995.

2- Anne, H. and Charlane, P.: Hand Function in the Child "Foundations for Remediation". Mosby-Year Book, Inc.1995.

3- Berry, E.K., Buktencia, N.A. and Berry, N.A.: Developmental test of visual motor integration: Administration, Scoring and teaching manual. 5th ed. Western Psychological services, Los Angeles 2004.

4- Duff, S.V. and Gordon, A.M.: Learning of grasp control in children with hemiplegic cerebral palsy. Dev Med Child Neurol., 45: 746-757, 2003. [CrossRef] [ISI] [Medline].

5- Duque, J., Thonnard, J.L., Vandermeeren, Y., Sebrie, G. and Cosnard, G.: Correlation between impaired dexterity and corticospinal tract dysgenesis in congenital hemiplegia. Brain. 126: 732-747, 2003.

6- Eliasson, A.C., Gordon, A.M. and Forssberg, H.: Basic co-ordination of manipulative forces in children with cerebral palsy. Dev Med Child Neurol. 33: 661-670, 1991. [ISI] [Medline].

7- Eliasson, A.C., Gordon, A.M. and Forssberg, H.: Impaired anticipatory control of isometric forces during grasping by children with cerebral palsy. Dev Med Child Neurol., 34: 216-225, 1992. [ISI] [Medline].

8- Eliasson, A.C., Gordon, A.M. and Forssberg, H.: Tactile control of isometric fingertip forces during grasping in children with cerebral palsy. Dev Med Child Neurol. 37: 72, 1995. [ISI] [Medline].

9- Forssberg, H., Eliasson, A.C., Redon-Zouitenn, C., Mercuri, E. and Dubowitz, L.: Impaired grip-lift synergy in children with unilateral brain lesions. Brain. 122: 1157-1168, 1999. [Abstract/Free Full Text].

10- Gibson, E.J. and Spelke E.S: The development of perception. In P.H. Musse (Ed.). Handbook of child Psychology (Vol. II). New York: Wiley 1983.

11- Gordon, A.M. and Duff, S.V.: Fingertip forces during object manipulation in children with hemiplegic cerebral palsy. I: anticipatory scaling. Dev Med Child Neurol.41: 166-175, 1999. [CrossRef] [ISI] [Medline].

12- Greenberg, D.A., Aminoff, M.J. and Simon, R.P.: Motor Deficits. Clinical Neurology. 5th ed. Division of the McGraw-Hill Companies, USA; 157-158, 2002.

13- Hanna, S.E., Law, M.C. and Rosenbaum, P.L.: Development of hand function among children with cerebral palsy: growth curve analysis for ages 16 to 70 months [published correction].

14- Hartveld, A. and John, M.: Computer as augmented feedback in gross movement training. Part 1: Motor skill acquisition. Keynotes, 2: 33-36, 1996.

15- Hofeston, C.: The organization of arm and hand movements in the neonate. In: Von Euler C, 2nd ed. The Neurobiology of early infant behavior. London, England: Macmillan Ltd; 129-142, 1993.

16- Hull, C.: Effect of stimulus novelty on manipulatory exploration of an infant. Journal of Child Psychology and Psychiatry, 8: 241-247, 1967.
17- Lawerence, D.G. and Kuypes, H.G.: The Functional organization of the motor system in the monkey.1.The effects of Bilateral pyramidal lesions. Brain, 91: 1-1, 1968.
18- Lewthwate, R.: Motivational considerations in physical activity involvement. Physicaltherapy; 73(12), 685-688, 1990.
19- Merrill, S.C. and Mulligan, S.E.: Neurological dysfunctions in children. In: Crepeau, E.B., Cohn, E.S. and Schell, B.A.; Occupational Therapy. 10th ed. Lippincott Willians and Willkins, A Wolters Kluwer Company, Philadelphia, USA; 702-703, 2003.
20- Muir, R.B. and Lemon, R.N.: Corticospinal neurons with a special role in precision grip. Brain research, 261: 312-316, 1993.
21- Passingham, R.E.: Changes in size and organization of the cortical functions in man and other primates. International Review of Neurobiology; 16: 233, 1975.
22- Richard, L., Palmiter-Thomas, P.: Grip strength measurement: A critical review of tools, methods, and clinical utility. Critical Review in physical and a rehabilitation Medicine.; 46: 87-109, 1996.
23- Robertson, K.: A randomized controlled trail of computer-based cognitive rehabilitation for unilateral left visual neglect. Archives of Physical Medicine and Rehabilitation, 71: 663-668, 1990.
24- Warren, E.: Sensory integration and the child. Los Angles, C.A.: Western Psychological Services 2001.
25- Warren, K.: Sensory integration and the child. Los Angles, CA: Western Psychological Services 2001.
26- Ziviani, J. and Lane, A.: Children's Computer Access; Analysis of the Visual-motor demands of software designed for children. British journal of Occupational therapy; 62; 19-25, 1999.

الملخص العربي

التناغم بين العين والأداء الدقيق لليد في حالات الأطفال المصابين بالشلل النصفي الطولي

ملخص البحث : إن الطفل الذي يولد بنقص في الوظائف الحيوية للمخ كنتيجة لإصابته بالشلل المخ ي يعانى من أثر هذه الإصابة على استخدامه للعديد من أجزاء الجهاز العضلي الحركي بالإضافة إلى ما تحدثه هذه الإصابة من أثر على العديد من المراكز الحسية في الجسم والتي قد تشمل اصابة العين أو اضطرابا في الإدراك البصري بالرغم من سلامة كلآ من العينين والعصب البصري المغذى لهما. وغالبا ما يصاحب ذلك ضعف في المهارات الوظيفية عند الطفل وخاصة المهارات الحركية الدقيقة لليدين فضلا عن ضعف المهارات الحركية الجثمانية للطفل . تم أجراء هذا البحث لدراسة مدى الارتباط بين تحسن الإدراك البصري باستخدام التقنية الحديثة ممثلة في استخدام المحاكاة الكمبيوترية واستخدام برنامج مبسط يحتوى على ألعاب مبسطة ذات أهداف خاصة ومقدمة للطفل بصورة شيقة (كمصدر للتغذية الاسترجاعية) على تحسين ال تناغم الحكى بين العين واليد عند الأطفال المصابين بالشلل المخي الطولي . **مواد البحث وأساليبه :** تم إجراء هذا البحث على أربعة وعشرون طفلاً مصابون بالشلل المخي النصفى . وقد تم اختيار هؤلاء المرضى من الجنسين (14 بنتا و10 أولاد) تراوحت أعمارهم بين ستة إلى ثماني سنوات . وتم اختيارهم يعانون من درجة خفيفة من التقلص العضلي في اليد المصابة . وقد تم اختيار هؤلاء الأطفال من العيادة الخارجية للأطفال بكلية العلاج الطبيع ي - جامعة القاهرة . وقد تم تقسيم الأطفال عشوائيا إلى مجموعتين . تلقت المجموعة الأولى برنامج معد لتحسين وظائف اليد و تلقت المجموعة الثانية التدريب على جهاز الكمبيوتر وذلك بعرض ألعاب مبسطة على شاشة الجهاز متدرجة في عدد الخلايا المكونة للتدريب ابتداء من اثنتين وحتى اثنتي عشر خلية ومتدرجة أيضا في صعوبة الحركات المطلوبة من تحريك فأرة الجهاز في الاتجاهات المختلفة للوصول إلى الهدف المطلوب من التمرين . وتم تقييم قوة قبضة اليد ومهارات الإدراك البصري باستخدام مقياس البيبودى للأطفال في كلا من المجموعتين قبل بدء العلاج وبعد ثلاثة أشهر من تطبيق برنامجي العلاج . وقد تمت المقارنة الإحصائية للمتغيرات المقاسة بين كلتا المجموعتين . **النتائج :** أظهرت النتائج عدم وجود فروق ذات دلالات إحصائية بين المجموعتين قبل تلقى العلاج . كما أظهرت النتائج وجود فروق ذات دلالات إحصائية بعد ثلاثة أشهر من بدء العلاج بين المجموعتين لصالح المجموعة الثانية . **التوصيات :** بناءا على نتائج هذا البحث ؛ تم التوصية باستخدام أجهزة الكمبيوتر والبرامج المجهزة لتأهيل ألأطفال ذوى الاحتياجات الخاصة في وحدات التأهيل المختلفة لتحسين مهارات الإدراك البصري والمهارات اليدوية الدقيقة في حالات الأطفال المصابين بالشلل المخي النصفى .