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Predictability of Hand Skills after Cognitive Remediation Therapy in Down Syndrome

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ABSTRACT

Background: Cognitive remediation therapy (CRT) is a non biological treatment that aims at correcting cognitive deficits through repeated exercises. Its efficacy in patients with Down syndrome is not well recognized yet, as children with Down syndrome have visual-perceptual dysfunction as a result of limited sensory experience from the lack of normal motor control. **Objective:** The purpose of the present study was to assess the impact of the RehaCom software as a cognitive remediation therapy in performance of fine motor skills in children with Down syndrome. **Methods:** Twenty-six children with Down syndrome with age ranged between seven and ten years participated in this study. All those children showed average intelligence level. First, evaluation of fine motor dysfunction by Peabody Developmental Measuring Scale 2 (PDMS-2) and the visual perceptual test reaction duration (maximal and minimal) was detected for each child. Then, children were divided into two equal groups: a control and a study group. Therapy program for enhancing fine-motor skills was given to the two groups. In addition, children within the study group received Visual-perceptual integrative therapy program (Rehacom). Post treatment evaluation was done after three months. **Results:** At the end of the treatment, children within the study group showed a significant improvement with regard to grasping, fine-motor quotient and maximum and minimal reaction time of visual perceptual test performance ($P<0.05$). **Conclusion:** Visual-perceptual training improves fine-motor skills performance in children with Down syndrome.

Key words: Visual perception, Cognition, Hand skills, Down syndrome.

INTRODUCTION

Down syndrome is the world's most common chromosomal disorder that causes intellectual disability. It is not an illness or disease, and it occurs at conception. The incidence of down syndrome is one in every 700 to 900 births worldwide and it affects people of all ethnic and social backgrounds[10]. Down syndrome is a disability that is characterized by significant limitations both in intellectual functioning and in adaptive behavior as expressed in conceptual, social, and practical adaptive skills. In children with Down syndrome, there have been a number of observed and measured motor characteristics such as hypotonicity, joint hypermobility, reduced deep tendon reflexes, persistence of primitive reflexes, and a delay in the appearance of reaction timing and equilibrium reactions that may have contributed to delayed development[13]. Various studies have shown that children with Down syndrome generally have deficits in eye-hand coordination, laterality, speed, reaction timing, equilibrium and visual motor control[5,14,15].

There is evidence supporting that children with Down syndrome demonstrate impairments in perceptual-motor coupling. For example, when children with Down syndrome perform motor tasks requiring anticipatory actions (such as catching), their impairments appear to be attributable to difficulties in regulating the temporal aspects of their actions[13]. Charlton et al.,[2] reported that children with Down syndrome have difficulty in properly adjusting both the spatial and temporal aspects of their grasp as a function of object size or task goal. Difficulties in the use of the perceived object properties in action planning may point to a dysfunction in relating information about limb position with respect to the environment to task demands.

Early intervention approaches for facilitating fine-motor development in infants and children with Down syndrome have traditionally emphasized the acquisition of motor milestones. As increasing evidence suggests that fine- motor milestones have limited predictive power for long-term motor outcomes, researchers have shifted their focus to understanding the underlying perceptual-motor competencies that influence motor behavior in Down syndrome[8].

Cognitive and perceptual deficits are two of the most puzzling and disabling difficulties that a person can experience. Thinking, remembering, reasoning and making sense of the world around us is fundamental to carrying out daily living activities. The perceptual-motor process is a chain of events through which the individual selects, integrates and interprets stimuli from the body and the surrounding environment. Basically perception includes both cognition and visual perception as sub components[11].

The growing interest in recovery has led to development of multiple therapeutic strategies for cognitive rehabilitation, that is, the remediation or alleviation of cognitive deficits resulting from neurological damage[16]. Cognitive rehabilitation is an interactive and dynamic training process involving the patient and treatment team[9]. The biological basis of its amelioration of neuropsychological sequelae resides in brain neuroplasticity[4,9].

SUBJECTS AND METHODS

Subjects

A non randomized controlled clinical trial was conducted on twenty-six Down syndrome children, aged 7 to 10 years old. Children were selected from the El Tarbia El Fekria School for children with special needs and the study was conducted at Rehacom laboratory, Faculty of Physical therapy, Cairo University. To maintain homogeneity of the samples, children were selected according to predetermined criteria including: (1) being able to do reaching with grade 3; according to a modified functional reaching scale, and (2) their IQ level was within average ≥ 70 according to (Stanford-Beneh) test. The study was approved and conducted in accordance to the standards of the Ethics Committee of the Faculty of Physical Therapy at Cairo University. First, a written informed consent was obtained from the parents and /or guardians of all participants. Then, the children were assigned to the control (n=13) or study group (n=13).The both groups received a selected hand function training program. The study group additionally received an attention and concentration training program, using the Rehacom system. All participants received 36 training sessions ;3 sessions per week for 3months. Patients were closely monitored for possible negative effects during training.

Instrumentations:

Peabody Developmental Motor Scale 2 (PDMS-2) was used for evaluation of fine motor abilities for each child in the two groups.

RehaCom software was used for evaluation of cognitive abilities for each child in the two groups and it was also used for treatment of children in the study group; starting from the level where they ended in evaluation.

Evaluation procedures:

Children in both groups were subjected to evaluation of their cognitive abilities using Rehacom system. The system consists of a basic assessment program and number of training procedures that are used for cognitive function assessment and training. Clinical usefulness of the software has been assessed by using the dynamics which is a personalized increase in task difficulty level according to individual patient progress.

All RehaCom protocols have varying levels of difficulty which were introduced automatically on the screen when the patient performed the previous task successfully in support of training for the following cognitive level. Each child in both groups was evaluated starting from level eight at the start and end of the study.

Peabody Developmental Motor Scale 2 (PDMS-2)

PDMS-2 is an early childhood motor development scale that is used for assessment and training of gross and fine motor skills. The assessment is composed of six subtests that measure interrelated motor abilities that develop early in life. Grasping: This 26-item subtest measures a child's ability to use his or her hands. It begins with the ability to hold an object with one hand and progresses up to actions involving the controlled use of the fingers of both hands. Visual-Motor Integration: This 72-item subtest measures a child's ability to use his or her visual perceptual skills to perform complex eye-hand coordination tasks such as reaching and grasping for an object, building with blocks, and copying designs. Fine Motor Quotient (FMO): It is a composite of the results of the two subtests that measure the use of small muscles. Scoring criteria and record of scores: After administration of all tests in grasping, raw scores were expressed as the total points accumulated by a child on each subtest. Also standard score of each subtest was converted form raw scores of that subtest. The PDMS-2 is based on scoring each item as follows: 2: The child performs the item according to the criteria specific for mastery. 1: The child performance shows a clear resemblance to the item mastery criteria but doesn't fully meet the criteria. 0: The child cannot or will attempt the item, or the attempt doesn't show that skill is emerging.

Treatment procedures:

Cognitive rehabilitation using RehaCom software: interactive computerized cognitive rehabilitation was demonstrated for each child in the study group individually. The RehaCom includes activation and stimulation of several cognitive domains such as attention, memory, visual-spatial processes and executive functioning. The program contains several modules with different levels of difficulty. Recording the number of errors and test completion time for all patients and a training results file enabled continuity over several sessions and database storage of results. Computer gave patients appropriate feedback on performance. Attention and concentration program is composed of 24 ascending difficulty levels. During treatment application, the following parameters were considered: Acoustic feedback parameter and limited solution time. Limitation depends on the level of difficulty, for the easiest task in the first level, one minute was given. In each level, the limitation expanded for 5 seconds for the most difficult it is 3 min and 15 sec, and stop on errors.

The hand function training program that all children were given 3 sessions per week, 1 hour per session, included exercises to facilitate hand function based on reaching, grasping, release, carrying and more complex skills of in-hand manipulation and bilateral hand use. Each child was asked to do many activities such as grasping and transferring cube, removing and placing pegs, releasing cube, building towers with 3 cubes, manipulating paper, turning pages, constructing puzzles, writing activities, and cutting paper by using scissor.

RESULTS

A total 26 children with Down syndrome and their parents were recruited in the current study. Table 1 shows the mean age ± standard deviation (Mean ± SD). The children in the control group were 8.31 years ± 1.11, whereas those in the study group were 8.23 years ± 1.09. The percentage of girls to boys in the control group and study groups were 38.46% and 61.54% and 30.77% and 69.23%, respectively.

Table (1): Demographic characteristics for subjects in both groups.

	Control group n=13	Study group n=13
Age (yrs.)	Mean ±SD 8.31 ± 1.11	Mean ±SD 8.23 ± 1.09
Sex (G/B)	n(%) 5/8 (38.46%/61.54%)	n(%) 4/9 (30.77%/69.23%)

N: number yrs: years G: girls B: boys

Unpaired t test was used to show difference between the two groups regarding attention and concentration level. Pre-treatment Mean ± SD for both control and study groups were (1.38 ± 0.65) and (1.46 ± 0.66), respectively revealed no statistical significant difference with t = 0.299 and p- value = 0.767. On the other hand, post treatment Mean ± SD for both groups were (5.77 ± 1.09) and (3.46 ± 1.56) respectively with t = 4.368 and p value = 0.001, showed a statistically significant difference.

As shown in table 2 Pre-treatment $\bar{x}$ ± SD of maximum reaction time (second or milli seconds) for both control and study groups were (45232.00 ± 2333.47) and (46532.08 ± 4318.75), respectively; with t test = 0.955 and p value = 0.349. The average minimum reaction time were (1638.15 ± 435.73) and (1835.69 ± 507.62), respectively, with t = 1.065 and p-value 0.298 indicating a non-significant difference between the two groups.

Regarding Minimal reaction time, the results showed a statistically significant reduction of the time as mean values for both control and study groups after treatment were (1400.31 ± 475.88) and (768.38 ± 239.57), respectively, with t test = 4.277 and p value = 0.001 (Table 2).

Table (2): Compassion of Attention & concentration levels and reaction time before and after treatment for both groups.

variable	Control group Mean ± SD	Study group Mean ± SD	t-vale	P value
Att.& Con. Level				
Pre	1.38± 0.65	1.46 ± 0.66	0.299	0.767
Post	3.46 ± 1.56	5.77 ± 1.09	4.368	0.001*
Max. Rea. Time (msec)				
Pre	45232.00 ± 2333.47	46532.08 ± 4318.75	0.955	0.349
Post	33634.77 ± 2817.25	28115.38 ± 2254.85	5.515	0.001*
Min. Rea.Time (msec)				
pre	1638.15± 435.73	1835.69 ± 507.62	1.065	0.298
post	1400.31 ± 475.88	768.38± 239.57	4.277	0.001*

*: Significant SD: standard deviation Max: Maximum Min : Minimum

As shown in Table 3, Pre-treatment average grasping scores for control and study groups were 2.15 ± 0.80 and 2.54 ± 1.27, respectively, with t test = 0.926 and p value =0.364 indicating statistically insignificant differences. Pre- treatment average visual motor integration for control and study groups were 3.15 ± 0.38 and 3.08 ± 0.28, respectively; with t = 0.594 and p value = 0.558 , showing a statistical insignificant difference. The average fine motor quotient for both control and study groups were 55.92 ± 2.56 and 56.85 ± 4.51, respectively; with t= 0.642 and p=0.527 revealing statistically insignificant difference.

Table (3): Comparison of Pre- and post-treatment standard score of grasping, VMI and Fine motor quotient for both groups.

Variable	Control group	Study group	t	p

	Mean ± SD	Mean ± SD		
Standard score grasping				
Pre	2.15 ± 0.80	2.54 ± 1.27	0.926	0.364
post	3.77 ± 1.96	5.92 ± 2.10	2.701	0.012*
Standard score VMI				
Pre	3.15 ± 0.38	3.08 ± 0.28	0.594	0.558
post	3.92 ± 0.28	4.85 ± 0.90	3.539	0.002 *
Fine motor quotient				
Pre	55.92 ± 2.56	56.85 ± 4.51	0.642	0.527
post	63.08 ± 6.29	72.31 ± 6.94	3.552	0.002 *

*: Significant SD: standard deviation

On the other hand, post treatment average grasping score of study group and control groups were 5.92 ± 2.10 and 3.77 ± 1.96, respectively; with t test = 2.701 and p value = 0.012 . While post treatment average visual motor integration of control and study groups were 3.92 ± 0.28 and 4.85 ± 0.90, respectively; with t test = 3.539 and p value = 0.002 showing a statistically significant change in favor to the study group. Post treatment average fine motor quotient of study group was 72.31 ± 6.94, whereas that of the control group was 63.08 ± 6.29; with t test = 3.552 and p value = 0.002 showing a statistically significant difference in favor to the study group.

DISCUSSION

This study is the first to investigate the impact of cognitive remediation therapy (RehaCom) on fine motor performance in children with Down syndrome. Cognitive functions concerning attention and concentration abilities were measured at the beginning of treatment by Rehacom system, in both control and study groups, showed a decrease in levels of attention and concentration, and increase in maximum, median and minimum reaction time. Children with Down syndrome have some degree of mental disabilities that reflects the cognitive impairment which is supported by Mark[7], who reported that the most common condition associated with Down syndrome is cognitive impairment as cognitive development is often delayed, and all individuals with Down syndrome have moderate to severe learning difficulties that last throughout their lives. He also stated that the average brain size of a person with Down syndrome is small. Scientists have reported alterations in the structure and function of certain brain areas such as the hippocampus and cerebellum in those children. Specifically, the hippocampus, which is responsible for cognitive function[7].

The improvement regarding grasping and VMI scores in both groups may be attributed to the use of different tools with different colors, sizes, shapes, and textures, which were attractive and motivating to children to complete the task in an acceptable form. This has been supported by Wilton[17], who recommended that treatment of hand dysfunction should receive greater attention of physical and occupational therapists, as poor grasp and manipulation have a potential negative impact on various aspects of daily living. He added that, there is increasing evidence of the value of therapy that is directed to functional outcomes relevant to the individual.

The significant difference in scores of grasping and visual motor integration in post treatment evaluation between study and control groups could be attributed to the improvement of grasping and visual motor integration as a result of combination between hand function training program and using different exercise by computer program. This could have facilitated the attention and concentration during training, and hence, might have increased the fine motor abilities of the child.

Improvement in the study group may be attributed to auditory feedback of Rehacom system that formed a positive verbal feedback. This in turn could have enabled the child to pay more attention and concentration before selection, and thus, improved his/her performance.

Motivation and encouragement produced by Rehacom system through gradual progression in level of difficulty is an attractive form that motivated children to exert their maximal effort in order to hear or see the sign indicating the correct answer. Also, using Rehacom screen which displayed pictures with different shapes and colors maintained the child attention and concentration for longer period of time, which is supported by Bertenthal and Von Hofsten[1] who reported that the vision is particularly important in learning new motor skills.

The current results are in agreement with those findings of Lewis and Russel[6] who stressed the effect of motivation and its relationship to improving physical activities. They investigated the effects of personal, social and environmental motivation on enhancing performance using effective motivational tools.

The results of the current study are also in agreement with Cook and Woollacot[3] who stated that normal upper extremity functions, including the ability to reach for grasp and manipulate objects, are the basis for fine motor skills which are important to activities of daily living such as feeding, dressing, grooming, and handwriting. They reported that the upper extremity control is intertwined with both fine and gross motor skills. Thus, recovery of the upper extremities function is an important aspect of retraining the patient in most areas of rehabilitation.

These results may also be explained by improvement of visual cognitive components ,which included visual attention, memory, discrimination, and VMI. O'sullivan & Schmitz[11] suggested that increasing attention and concentration occurs by improving alertness, vigilance selective, divided or shared attention, enhancing integration of visual information with previous experiences, improving the ability to detect features of stimuli for recognition, matching and categorization.

CONCLUSION

With the limitation of this study, cognitive remediation therapy has a positive impact on fine-motor performance in Down syndrome children.

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الملخص العربي

التنبؤ بمهارات اليد بعد العلاج المعرفي في الأطفالالمصابين بمتلازمة داون

العلاج المعرفي هو معالجة غير بيولوجية تهدف إلى تصحيح العجز المعرفي عن طريق التدريبات المتكررة. لم يتم التعرف على فاعلية هذا النوع من العلاج على المرضى الذين يعانون من متلازمة داون بشكل جيد حتى الآن حيث أن الأطفال الذين يعانون من متلازمة داون لديهم في قدرات الإدراك البصري نتيجة لضعف كلاً من الخبرة الحسية ونقص في التحكم الحركي الطبيعي . **الهدف :** كان الهدف كإحدى وسائل المعالجة المعرفية على الأداء الحركي الدقيق في أطفال متلازمة داون Rehacom من هذه الدراسة تقييم تأثير . **الأساليب :** تم اختيار ستة وعشرون طفلا مصابا بمتلازمة داون تراوحت أعمارهم بين 7 إلى 10 سنوات متوسطي مستوى الذكاء وقد تم تقسيمهم إلى مجموعتين متساويتين في العدد . تم بعد ذلك تقييم ضعف الحركية الدقيقة باستخدام مقياس البيبودي كمقياس للنمو كما تم أيضا قياس الحد الأقصى ، والمتوسط، والحد الأدنى من متوسط وقت رد الفعل لاختبار الإدراك الحسي البصري وجرى تقييم كل طفل في كلتا المجموعتين قبل وبعد ثلاثة أشهر من تطبيق العلاج. أعطيتا لمجموعة الضابطة برنامج علاج لتعزيز المهارات الحركية الدقيقة التحكم . Rehacom بينما أعطيت المجموعة الدراسة نفس البرنامج بالإضافة إلى برنامج تنبيه الإدراك الحسي . **النتائج :** أظهرت النتائج أن هناك تغير ذو دلالة إحصائية في كل من المجموعتين تشمل كلاً من القدرة الحركية على استخدام اليد ونقص في الحد الأقصى والمتوسط ، والحد الأدنى من متوسط وقت رد الفعل من أداء اختبار الإدراك الحسي البصري بعد مدة العلاج المقترح مع المزيد من التحسن لصالح المجموعة الدراسة : النتائج (< 0.05) . **الاستنتاج :** التدريبات المعرفية لها تأثير إيجابي على أداء المهارات الحركية الدقيقة في أطفال متلازمة داون .