Influence of Elbow Immobilizer on Hand Function in Children with Athetoid Cerebral Palsy

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ABSTRACT

The purpose of this study was to investigate the effect of using elbow immobilizer during the application of occupational therapy program on improving the hand function in children with athetoid cerebral palsy (CP). Forty children with athetoid CP of both sexes (18 girls and 22 boys); their ages ranged from five to eight years (mean age 6.51 ± 0.97 years), participated in this study. They had fluctuating tone in the upper limb, involuntary movement in form of athetosis and could sit alone or even with support. Children were randomly divided into two groups of equal number; study and control groups. Children in study group received a designed occupational therapy program while wearing the elbow immobilizer. Those in control group received the same occupational therapy program without wearing the elbow immobilizer. Treatment was conducted three times / week for successive three months to both groups. Hand function was evaluated before and after treatment by using the Grasp and Release Test (GRT) and the Peabody Developmental Motor Scale-2 (PDMS-2). The post-treatment results showed a statistically significant improvement of the GRT in both groups (in favor of the study group). Moreover, there was a significant improvement of the PDMS-2 scores in the study group. The present study concluded that wearing elbow immobilizer during the application of occupational therapy program has a potential benefits to improve the hand function in children with athetoid CP.

Keywords: *Elbow immobilizer, Hand function, Athetosis, Cerebral palsy, Occupational therapy.*

INTRODUCTION

Cerebral palsy (CP) is a well-defined neurodevelopmental condition beginning in infancy and persisting throughout life. It encompasses a group of disorders in the development of movement and posture that cause activity limitations and are attributed to non progressive disturbances occurring in the developing fetal or infant brain[1]. Based on the clinical signs, there are several types of children with CP which include spastic, dyskinetic, hypotonic, ataxic, and mixed types. Dyskinetic CP has several forms as athetosis, dystonia, chorea and tremors. Athetosis is the most common form, which is characterized by slow involuntary movement of the face and extremities particularly affecting the distal musculatures2.

Athetoid CP, like all CP types, is caused by brain damage. The damage creating athetoid CP symptoms is located in the cerebellum or basal ganglia. These areas of the brain help in controlling the movement. Specifically, the cerebellum and basal ganglia are responsible for processing the nerve signals enabling coordinated, smooth movement and maintaining body posture. Damage to these areas can make people develop slow, random, involuntary movements[3].

Athetoid CP is characterized by fluctuations in muscle tone between being too tight and too loose. It usually affects the whole body instead of a particular region. Interestingly, a large percentage of people with athetoid CP have above average intelligence. Children with athetoid CP have trouble holding themselves in an upright, steady position for sitting or walking, and often show lots of movements of their face, arms and upper body that they don't mean to make (random, involuntary movements). These movements are usually big. For some kids with athetoid CP, it takes a lot of work and concentration to get their hand to a certain spot (like to scratch their nose or reach for a cup). Because of their mixed tone and trouble keeping a position, they may not be able to hold onto things (like a toothbrush or fork or pencil)[4].

Orthotic treatment was defined as the application of an external force generated by an appliance worn by a client. These forces, although biomechanically designed, have significant neurological implications related to the input that they provide to the CNS. Orthosis can be used as an adjunct to a sound therapeutic exercise program to hasten the desired result of the client's treatment program, but orthotic intervention never replace a sound therapeutic exercise program[5].

Upper limb (UL) orthoses are used frequently with patients who suffer from neurological problems, such as stroke, traumatic brain injury, multiple sclerosis, cerebral palsy, spinal cord injury and peripheral nerve injury[6]. They may be used to substitute for absent motor power and assist of weak segment. They may also be used to support segments requiring static positioning and immobilization either full or part time, block unwanted movement of a joint and increase range of motion[7].

Most of the literature on splinting hand problems is on spasticity management, while there is no existing literature of experimental research concentrated on the usage of upper limb splints in controlling involuntary movement and hence improving hand function. Therefore, aim of this study was to determine the effect of wearing elbow immobilizer during the application of occupational therapy program on controlling the involuntary movement and on improving the hand function in children with athetoid CP.

MATERIAL AND METHODS

Subjects

Forty children with athetoid CP, their age ranged from five to eight years, represented the sample of this study. They were recruited from the pediatric physical therapy outpatient clinic of the Faculty of Physical Therapy, Cairo University, after their parental agreement to the participation in this study. They had the following criteria: fluctuating tone in the upper limb, involuntary movement in form of athetosis, ability to sit alone or even with support, and ability to follow simple verbal commands and instructions included in tests and training. Children with fixed upper limb contractures or deformities, previous surgical treatment in the upper limb, visual, auditory defects or autistic features were excluded from the study. Participants were randomly assigned into two groups of equal numbers (study and control groups). Children in the study group (eight girls and twelve boys), their mean age was 6.5 ± 1.02 years, received a designed occupational therapy program while wearing the elbow immobilizer. Children in the control group (ten girls and ten boys), their mean age was 6.54 ± 0.95 years, received the same occupational therapy given to study group without using the elbow immobilizer.

Instrumentations

For evaluation:

1- The Grasp and Release Test (GRT) was used as an evaluation tool to assess improvements of gross motor function of the hand, particularly lateral pinch and palmar grasps. It consists of six different objects that commonly and naturally used in activities of daily living (ADL), to be grasped and released by patients. The tool consists of two sets of tests, object manipulation and strength tests[8].

2- Peabody Developmental Motor Scale (PDMS-2) was used to evaluate the fine motor skills including grasping and visual motor integration. This scale provides a comprehensive sequence of fine motor skills, by which the therapist can determine the relative developmental skill level of a child, identify the skills that are not completely developed and plan an instructional a program that can develop those skills[9].

For treatment:

1. Universal elbow immobilizer: It is a one piece posterior gutter, used for simple fixation of the elbow in an extended position. It is made from a well padded parallel vertical bars (made of iron and covered with Peddling material). It encircles the elbow, extending about 10cm (more or less) up and down and fixed in position by velcro straps[10].
2. Mats, wedges, rolls, medical ball, chairs with different sizes and certain fine tools (e.g. cubes) were used for conducting the

physical and occupational therapy program.

Procedures

Evaluative procedures

All procedures were performed by a blinded evaluator at baseline (pre-treatment) and at the end of three successive months of treatment (post-treatment) in a warm, well lighted and quiet room. Hand function was assessed for all children participated in this study by using GRT and PDMS-2 as follows:

a-The Grasp and Release Test:

The GRT assesses the ability to pick up, move, and release five of six objects of varying sizes, weights and textures using a palmar or lateral grasp[8,11]. Each object was chosen to represent one or more objects routinely manipulated for activities of daily living (ADL) that represented a range of difficulties. Children were scored on their ability to successfully move each of the objects as many times as possible in 30 seconds. Each hand was tested and scored separately. The object manipulation test was the only set of the test that used in this study to evaluate how the child uses his/her palmar and lateral/pulp pinch grasps to test the palmar grasp, the child was presented with the following five items: mug, book, pop can, isosceles triangular sponge and mobile phone. To test the lateral or pulp pinch grasp, the child was presented with the following five items: paper sheet, zip-lock-bag filed with five golf balls, die, credit card and pencil. The objects were placed on a desk 20-30 cm in front of the child, one after another, in a pre-determined order. The child was asked to pick up each object, lifting it, and move the object then release it. The number of task repetition in 30 second for each object was scored then the sum of tasks repetitions of the ten objects used in the assessment was calculated for each child.

b- Peabody Developmental Motor Scale:

Each child was asked to sit on a chair-table that permits him/her to comfortably place feet on the floor. The table was large enough that allowed the examiner and the child to sit opposite each other or side by side. The examiner tested progressively the items in each subtests (grasping and visual motor integration) until a ceiling was established. After administration of all tests in each subtests, raw and standard scores were calculated for each one. Finally, fine motor quotient was determined. It was derived from the standard scores of the two subtests.

Treatment procedures

For study group:

Training the main motor aspects of hand function that involve the types of grasp, the pattern of reach and the pattern of release were applied to all children while wearing elbow immobilizer. The child was asked to sit on a chair-table and the therapist guided and assisted the child to perform the following training:

- Training of reaching that included reach for an object presented at midline with each hand, reach with 45° and 90° of shoulder flexion and neutral rotation of humerus and finally reach across midline while keeping an erect trunk.
- Use a sustained palmer grasp with wrist extension either grasping an object or maintained grasp on bars, handles, in front, at the side , above or below the child in sitting or standing position.
- Train grasp with finger tips opposed to the thumb, then grasp smaller object with the tips of index and thumb (precise pincer grasp).
- Release objects like cubes into a defined area or container then release smaller objects like pellets into cup and progress to small bottle.
- Building a tower from 2 to 8 cubes which was an example of training reach, grasp and release in one exercise.

In addition to the training the main motor aspects of hand function, all children received facilitation of postural mechanisms, bilateral and unilateral hand weight bearing, approximation, protective extensor thrust, and finally facilitation of the delayed gross motor milestones (e.g. standing, walking according the ability of each child).

For control group:

Children in this group received the same physical and occupational therapy program given to study group without wearing the

elbow immobilizer during training the main motor aspects of hand function.

The physical and occupational therapy program was conducted for successive three months, three times /week, two hours/session to all children participated in this study.

Statistical analysis

The mean and standard deviation were calculated for children age, GRT (number of tasks repetitions in 30 second) and fine motor quotient (FMQ) before starting the treatment and after three months (at the end) of treatment for both groups. The paired and unpaired t-test was used to compare the pre- and post-treatment values of GRT within the group and between the two groups (study and control groups) respectively. For non-parametric data, Wilcoxon signed-rank test and Mann-Whitney signed-rank test, were used to compare the results of FMQ within the group and between the two groups respectively. The results were considered significant if the p values were less than 0.05.

RESULTS

Six of forty children with athetoid CP did not complete the treatment period and were excluded from the data analysis. The remaining thirty four children, to whom the following findings refer, have been treated in this study. Fourteen (41.2%) of them were girls and twenty (58.8%) were boys. Their mean age was 6.51 ± 0.97 years. Both upper limbs were treated and each limb was included for analysis.

Grasp and release test and Peabody development motor scale were used to evaluate the hand function for children in this study. Concerning the GRT, the number of task repetition in 30 second for each object was scored then the sum of tasks repetitions of the ten objects was used in the analysis. Regarding the PDMS-2, Fine Motor Quotient (FMQ), which is the most reliable score yielded by PDMS-2, was used to measure the changes in hand function (grasping and visual motor integration) after our intervention in both groups.

Comparing the pre- and post-treatment values of GRT using paired t-test within the group showed a significant improvement in each study and control groups (P < 0.0001).The analysis across the group (between SG & CG) revealed no significant difference in pre-treatment results (P = 0.4746 for Rt. UL & 0.4139 for Lt. UL), while showed a significant difference in the post-treatment results in favor to the study group (P < 0.0001for each U L) (Tables 1, 2 and Figure 1).

Table (1): Comparison of the pre and post treatment mean values of GRT of both upper limbs for each group

Item	Pre X ±SD	Post X ± SD	t- value	P-value
Rt. U L				
Study group	13.52 ± 1.42	26.29 ± 2.88	21.369	0.0001*
Control group	13.17 ± 1.42	18.17 ± 2.29	20.616	0.0001*
Lt. U L				
Study group	13.71 ± 1.44	26.7 ± 2.86	33.083	0.0001*
Control group	14.12 ± 1.45	19.17 ± 2.5	16.706	0.0001*

X: mean SD: Standard Deviation t: Student test UL: Upper limb *: Significant

Table (2): Comparison of the pre and post treatment mean values of GRT of both upper limbs between groups

Item	Study group	Control group	t- value	P-value
Rt. U L				
Pre X ±SD	13.52 ± 1.42	13.17 ± 1.42	0.7236	0.4746 (NS)
Post X ± SD	26.29 ± 2.88	18.17 ± 2.29	9.067	0.0001*
Lt. U L				
Pre X ±SD	13.71 ± 1.44	14.12 ± 1.45	0.8278	0.4139 (NS)
Post X ± SD	26.7 ± 2.86	19.17 ± 2.5	8.153	0.0001*

X: mean SD: Standard Deviation t: Student test UL: Upper limb
*: Significant NS: Non-significant

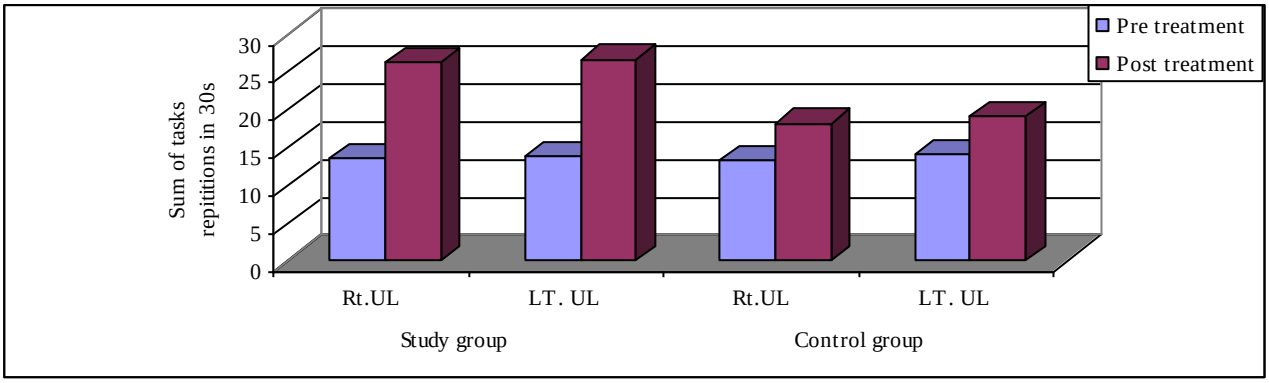

Fig. (1): Pre and post – treatment mean values of grasp – release test (GRT) of upper limbs (ULs) in study and control groups.

Comparison of the pre- and post-treatment values of FMQ, using the Wilcoxon signed- rank test, revealed a significant improvement in study group ($P < 0.0001$) and non significant improvement in the control group ($P=0.125$) for each upper limb. The analysis of FMQ values pre- and post-treatment across the group (between SG & CG) using the Mann– Whitney signed- rank test, revealed no significant difference in pre-treatment results ($P = 0.8756$ for Rt. UL & 0.7150 for Lt. UL), while showed a significant difference in the post-treatment results in favor to the study group ($P = 0.003$ for Rt. UL & 0.0081 for Lt. UL) (Tables 3, 4 and Figure 2).

Table (3): Comparison of the pre and post treatment mean values of FMQ of both upper limbs for each group

Item	Pre X ±SD	Post X ± SD	Z (sum of ranks	P-value
Rt. U L				
Study group	48.64 ± 2.57	53.05 ± 2.98	-153	0.0001*
Control group	48.47 ± 2.42	49.17 ± 3.26	-10	0.125 (NS)
Lt. U L				
Study group	49 ± 2.59	53.23 ± 3.01	-153	0.0001*
Control group	49.35 ± 2.57	50.05 ± 2.79	-10	0.125 (NS)

X: mean SD: Standard Deviation Z: Wilcoxon signed -rank test UL: Upper limb
*: Significant NS: Non-significant

Table (4): **Comparison of the pre and post treatment mean values of FMQ of both upper limbs between groups**

Item	Study group	Control group	U	P-value
Rt. U L				
Pre X ±SD	48.64 ± 2.57	48.47 ± 2.42	139	0.8756 (NS)
Post X ± SD	53.05 ± 2.98	49.17± 3.26	58	0.003 *
Lt. U L				
Pre X ± SD	49 ± 2.59	49.35 ± 2.57	133	0.7150 (NS)
Post X ± SD	53.23 ± 3.01	50.05 ± 2.79	67	0.008 *

X: mean SD: Standard Deviation U: Mann-Whitney signed-rank test
UL: Upper limb *: Significant NS: Non-significant

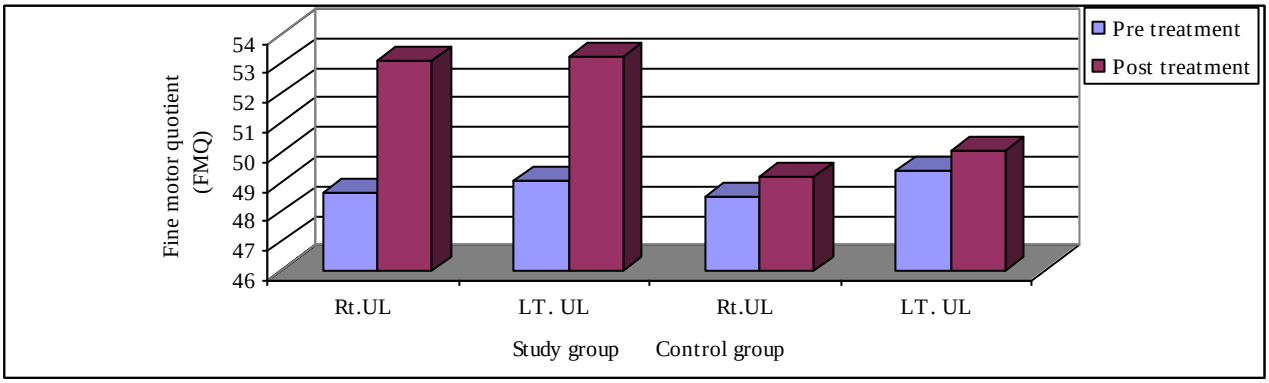

Fig. (2): Pre and post – treatment mean values of fine motor quotient (FMQ) of both upper limbs (ULs) in study and control groups.

DISCUSSION

The current study demonstrates that wearing the elbow immobilizer during fine motor training in addition to physical therapy program causes a significant improvement in hand function in children with athetoid CP.

Physical therapy is the cornerstone of therapy for athetoid dyskinetic cerebral palsy and all other forms of CP[12]. Currently, the use of different types of splints is coming more accepted in the expanding field of physical therapy[13].

The usage of different types of splints has been recognized over 30 years. Using different types of splints generated further interest of its effect on reducing spasticity and preventing soft tissues contracture. Moreover, braces and splints are described to block unwanted movement and to provide stability[14-16].

The collected data of the study and control groups before starting treatment revealed a delay in the development of motor aspect of hand function in children with athetoid CP which was manifested by a decrease in the mean values of the measuring variables (GRT & FMQ).This finding comes in agreement with Brown and Twitchell[17] who reported that the acquisition of fine motor skills are delayed in athetoid children as they suffer from slow development of postural mechanism.

A clinical and statistical improvement in hand function, as measured by GRT, was seen after three months of treatment in both groups. It was noticed that the percentage the improvement was higher in study group than that in the control group at the end of treatment. Regarding the study group, the percentage of improvements were 94.45% for Rt UL and 94.89% for Lt UL. While in the control group, the percentage of improvements were 37.96 % for Rt UL and 35.95 %for Lt UL.

The post-treatment increase in the mean value of GRT in both groups may be attributed to the development of stability around the proximal joints and reduction of the involuntary movement. The designed physical therapy program focused on the strategies to increase the stability and improve the postural control of the proximal parts. Weight bearing exercises and approximation were applied as a method to increase joint stability. Postural mechanisms were another methods used to improve postural fixation and control the involuntary movement. Increased stability and reduced involuntary movement allowed a good performance of the child during training of reach, grasp and release.

The results of the current study showed a clinical and statistical improvement in hand function, as measured by FMQ, in study group, but non statistical improvement was obtained in the control group. Moreover, significant differences have been observed between both groups in favor to study group after three months of treatment. As it was observed that the percentage the improvement was higher in study group than that in the control group at the end of treatment .Concerning the study group, the percentage of improvement was 9.15 % for Rt UL and 8.63 % for Lt UL. While in the control group, the

percentage of improvement was 1.2 % for Rt UL and 1.4 % for Lt UL.

Significant improvement of FMQ for study group may be attributed to the use of elbow immobilizer which help the child to perform a slow and smooth movement in the upper limb. In addition wearing the elbow immobilizer during training of fine motor skills gave the opportunity to the child for increased sensory input and successful practice throughout the treatment period.

As mentioned by Bobath and Bobath[18], the athetoid child is unable to reach forward for grasp and his grasp is weak and unsustained. He withdraws his hand instead of grasping when he is being presented with an object. Using elbow immobilizer during training of fine motor skills allowed the child to reach forward as the weight of the splint preventing the arm from pulling backward and withdrawal of the hand when trying to reach and grasp the object effectively.

Improvement noticed in hand function in the study group after three months of treatment may be resulted from combined effects of reduced involuntary movement and training of fine motor skills, in another words, the development of combined pattern of stability and mobility. These factors may help the child to perform the exercises and activities much better and store it as a memory. In addition, these combined effects may help the child to continue the corrections and readjustments of his/her performance using the two types of feedback (knowledge of performance and knowledge of results).

Non significant improvement of FMQ in the control group may be attributed to short treatment period which may not be enough to control the involuntary movement and allow the children in this group to participate more effectively in the fine motor training. In addition, the designed occupational therapy program concentrated on the training of main motor aspect of hand function (reach, grasp and release), but it did not focused on the more complex tasks (e.g. using a pencil, building different shapes by cubes, buttoning and unbuttoning), which were the main items in the PDMS-2. On the other hand, GRT is designed to assess the gross motor function of the hand such as grasp, move then release the object which was significantly improved in the control group.

The post-treatment results of FMQ and GRT revealed a significant difference between both groups in favor to the study group. This difference may be attributed to the effect of using elbow immobilizer during fine motor training in addition to the designed physical therapy program. This opinion agrees with Palmer and Shapiro[19] who described different types of splints to be used in treatment of CP beside the physical therapy program to achieve reasonable prognosis. Moreover, application of upper limb orthosis in this study agrees with King[20] who reported that motor abilities improved in cerebral palsied children receiving functional physical therapy including upper limb orthosis, more than in the CP children whose physical therapy was based on normalizing the quality of movement.

By using the elbow immobilizer, the child was able to perform the fine motor exercises in a nearly corrected pattern so, more normal sensory and motor awareness and motor learning process were acquired. In addition, the elbow immobilizer allowed the child to achieve his training for long time and in an effective way. This explanation comes in agreement with opinion of Garret [21] who stated that braces are used to control involuntary movements and so, enhance hand function through the development of useful patterns of motion.

The significant improvement noticed in hand function in study group may be due to reduced distal involuntary movement by wearing the elbow immobilizer during training of fine motor skills. It restricted the unwanted movement around the proximal joints (shoulder and elbow joints) which made easier for the child to control distal joint (wrist joint) and produce smooth movement.

On the same line, the finding of this study is confirmed by the work of Nicholson et al.[22] who assessed the upper limb function and movement in children with cerebral palsy wearing lycra garments. They found that the garments achieved better proximal stability and increased smoothness of movement in children with athetosis.

Similarly, the results of this study are supported by the study of Blair et al.,[23] who

investigated the effect of dynamic proximal stability splint in the management of children with cerebral palsy. They reported that functional gains were associated with splint wear. They added that more extensive Lycra body splinting in children with CP also showed improved dynamic upper limb function, with reduction in involuntary movement and improved patterns of movement associated with a reduction in muscle tone. In their study, they also found that thirteen of fourteen subjects experienced an immediate reduction in involuntary movement, with six maintaining some improvement after removal of the body splint.

Conclusion

The present study demonstrates that wearing the elbow immobilizer during the application of occupational therapy program has a potential benefits to improve the hand function in children with athetoid CP, through controlling the involuntary movement and allowing good and successful performance during fine motor training. It is recommended to be used during the application of occupational therapy program for such cases. Further studies are needed to investigate its effect on other types of dyskinesia as chorea or dystonia.

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الملخص العربى

تأثير مثبت مفصل الكوع على وظائف اليد عند الأطفال المصابين باضطرابات فى الحركة

تهدف هذه الدراسة الى تحديد تأثيرمثبت مفصل الكوع على وظائف اليد عند الأطفال المصابين بإضطرابات فى الحركة 0أجريت هذه الدراسة على اربعين من الأطفال المصابين بإضطرابات فى الحركه ، مما تراوحت اعمارهم من خمسة الى ثمانية اعوام ويعانون من حركات لإرادية فى الأطراف العلوية و قادرين على الجلوس بمفردهم أو مستندين ذاتيا . تم تقسيم هؤلاء الأطفال عشوائيا الى مجموعتين متساويتين فى العدد ، مجموعة الدراسة والمجموعة الضابطة . تلقت مجموعة الدراسة برنامج العلاج الوظائفى بإرتداء مثبت مفصل الكوع ، بينما تلقت المجموعة الضابطة نفس البرنامج بدون إرتداء مثبت مفصل الكوع . استمرت الدراسه ثلاثة شهوربواقع ثلاث جلسات اسبوعيا0تم تقويم وظائف اليد بإستخدام مقياس الامساك و الترك و كذلك مقياس البيى بودى قبل وبعد ثلاثة شهور من العلاج لكل من المجموعتين . وقد أظهرت النتائج تحسن واضح فى وظائف اليد بإستخدام مقياس الامساك و الترك للمجموعتين و لكن مع وجود فروق ذات دلالة إحصائية بينهما لصالح مجموعة الدراسة 0كما أوضحت النتائج ايضا تحسن ذو دلالة احصائية فى وظائف اليد بإستخدام مقياس البيى بودى فى مجموعة الدراسة فقط . ونستنتج من هذه الدراسة ان لمثبت مفصل الكوع دور فعال فى التحكم فى الحركات اللإرادية وتحسين وظائف اليد عند استخدامه اثناء تطبيق برنامج العلاج الوظائفى للأطفال المصابين بإضطرابات فى الحركة .

الكلمات الدالة : مثبت مفصل الكوع ، وظائف اليد ، اضطرابات الحركة ، الشلل الدماغى ، العلاج الوظفى .