Impact of Spandex Dynamic Splint on Hand Function in Spastic Hemiplegic Children

Fatma M. Abdelaty*† and Ehab M. Abd Elkafy*
*Department of Physical Therapy for Growth and Development Disturbances in Children and its Surgery, Faculty of Physical Therapy, Cairo University, Giza, Egypt.
†Corresponding author: Fatma M. Abdelaty (fmoustafa73@yahoo.com)
Tel. +202-25190923, +966-531836486

ABSTRACT

The purpose of this study was to determine the effect of Spandex dynamic splint on hand functions of hemiplegic children. Thirty hemiplegic children from both sexes ranged from 4 to 6 years old participated in this study. They were classified randomly into 2 groups of equal numbers; a control group (A) and a study group (B). Both groups received the same traditional physical therapy program and the same specially designed program for facilitation of hand function while wearing Spandex dynamic splint in group (B). The Peabody Developmental Motor Scale in the form of fine motor quotient (grasping and visual motor integration items) was used to evaluate hand functions before and after three months. The pre-treatment results revealed no significant differences between the two groups. Comparing the pre- and post-treatment mean values of the measuring variables of the two groups revealed significant improvements. However, comparing the post-treatment results of the groups revealed highly significant improvements in favor of group (B).
Keywords: Hemiplegia, Spandex dynamic splint, hand functions, children.

INTRODUCTION

Children with cerebral palsy suffer from neurological deficit that interfere with motor function. These impairments include neuromuscular and musculoskeletal problems as spasticity, muscle contracture, incoordination, defective motor control and muscle weakness. Also, such children may show a delay in the acquisition of various motor functions such as gross and fine motor skills (Gromly, 2001).

About 30% of children with cerebral palsy (CP) have hemiplegia with weakness and spasticity predominantly affecting one side of the body, including the arm, leg, and trunk musculature. Most children with hemiplegia are independent in both walking and most activities of daily life (ADL) (Rosenbaum, 2002).

Hemiplegic children has inability to use their hands for reach, grasp, and manipulation, which affect many of the activities of daily living such as dressing, eating and hand writing. Also, upper extremity function plays an important role in gross motor skills as crawling, walking recovering balance and protective reaction (Duff et al., 2001).

Grasping in spastic hemiplegic children is characterized by sustained forearm pronation which interferes with use of radial finger grasp patterns; wrist flexion with ulnar deviation in combination with finger extension; finger flexion lead to prevent opening of the hand; thumb adduction and lack of the ability to initiate or sustain thumb opposition (Embry, 1998).

Improvement of hand functions in hemiplegic children is considered a fundamental objective for helping the child to live independently as well as becoming conformed to his society. The aim of occupational therapy for children with hemiplegic CP is to optimize performance in tasks like playing or activities of daily living. There is more need for controlled studies to make evidence-based decisions in order to select the best treatment for a child with hemiplegic CP (Lukhan et al., 2009).

Many techniques and assistive device were invented and added in order to rehabilitate hemiplegic patients; one of them is Spandex dynamic splint (Nicholson, 2001).

Spandex dynamic splint system is one of the recent methods for physical and occupational therapy practices. Spandex dynamic splint is a stimulating system for neuromotor, postural, and sensory training. The system provides flexible approach to addressing and managing mobility, sensory input, and stability issues (Knox, 2003).

The present study was conducted to investigate the effect of a new assistive device "Spandex dynamic splint" and/or a designed physical therapy program on hand functions of hemiplegic children.

SUBJECTS, MATERIALS AND METHODS

Subjects

Thirty spastic hemiplegic children were diagnosed by a pediatric neurologist. The children were selected from both sexes with the following criteria:

1- The age of the children ranged from 4-6 years.

2- They were unable to use radial finger grasp (pincer grasp, writing activities, and bilateral hand use).

3- They had no contractures of wrist and forearm.

4- They were able to sit independently.

5- They were able to follow simple verbal commands or instructions.

6- They had no auditory or visual problems.

The children were classified randomly into 2 groups of equal number as follows:

Group A (control group): include 15 children received the traditional physical therapy program and specially designed program for facilitation of hand function without wearing Threatogs system.

Group B (study group): includes 15 children received the same traditional physical therapy program and specially designed program for facilitation of hand function while wearing Threatogs system.

Evaluation of hand function was carried out for each child individually before and after three months of treatment by using Peabody Developmental Motor Scale (PDMS2).

Materials for evaluation

(A)- Modified Ashworth scale:

This scale was used to determine the degree of spasticity (Appendix I).

(B)- Peabody Developmental Motor Scale (PDMS2):

The Peabody Developmental Motor Scales-Second Edition (PDMS-2) (Folio & Fewell, 2000) is a test of gross and fine motor development for children ages from birth to 6 years. The gross-motor component consists of four subtests: Stationary, Locomotion, Reflexes, and Object Manipulation. Two subtests, Grasping and Visual Motor Integration, make up the fine-motor portion. The test requires the child to perform specific motor items and is scored with a 2, 1, or 0 for each item, depending on whether the child correctly or partially complete the item, or does not complete the item according to its description. Standard scores, percentiles, and age-equivalents are available as well as quotient scores in fine- and gross-motor areas. The entire PDMS-2 can be administered in 45-60 minutes. Separate fine- or gross-motor subtest administration takes 20-30 minutes.

Materials for Treatment

(A)-The Spandex dynamic splint consists of the following parts:

1-One Thumb and Wrist Unit, designed for either the left or the right hand.

2- One Forearm Cuff.

3- Three Split Straps in 2 configurations (vary by kit size).

4- One Stretch Strap.

5- Assorted Velcro closure tabs.

6- Double-Gripper Velcro.

7- Marking Dots.

Other procedures used in treatment

A chair with adjustable height and back support, a table with a suitable height, cubes, pellets, bottle, papers, markers, form board and different forms, square beads and heavy string or rope, puzzles, clay of different colors, blunt scissors, rolls, balls, wedges and mats are all utilized during treatment.

Methods for evaluation

(A) Modified Ashworth Scale: used to determine the degree of spasticity (Appendix 1).

(B) Peabody Developmental Motor Scale (PDMS2):

Each child was evaluated with the Peabody Developmental Motor Scales-Second Edition that consists of 26-item grasping and 72-item visual-motor integration subtests.

a) Test Administration:

The entry points, basal points, and ceiling were used on grasping and visual-motor integration but one for each subtest to shorten testing time.

b) Record of score:

After administration of all testes in each subtests (grasping and visual motor integration), raw and standard scores were calculated for each one. Age equivalent was determined based on the raw scores obtained for each child. Finally, fine motor quotient was determined.

Methods for treatment

Each Patient in both groups (group A: not wearing Spandex dynamic splint, group B: wearing Spandex dynamic splint) received 3 sessions per week of traditional physical therapy program as well as specially designed program for facilitation of hand function for 3 months.

Traditional physical therapy program

The program consists of the following:

1- Approximation as a proprioceptive training for the upper and lower limbs and trunk.
2- Stoop and recover exercise.
3- Hand weight bearing exercises.
4- Training the righting and equilibrium reactions to improve the postural control.
5- Training the protective reactions to improve the postural control.
6- Activities in standing with weight on both legs.
7- Activities in standing with concentration of the Weight on the affected leg.
8- Gait training activities.
9- Walking up and down stairs.

Program for facilitation of hand function (selected exercises from Peabody Developmental Motor Scale [PDMS2])

The hemiplegic child was seated in a chair-table with his or her feet being on the floor, providing that the table should be large enough to allow the examiner and the child to sit opposite to each other's or side by side. Only those test materials needed to administer single item should be on the table at one time. All other materials should be within the examiner's reach but out of the child's view.

The program consists of the following

1- Building tower by cubes (using the affected hand).
2- Building different shapes with cubes (like bridge, wall, steps, and pyramid with the affected hand).
3- Inserting shapes on form-board (using the affected hand).
4- Folding paper.
5- Stabilize materials with unaffected hand while the affected hand manipulates materials (ask child to hold a cup while pouring liquid into it).
6- Stabilize material on a table surface with unaffected hand while the affected hand manipulates material (ask child to draw intersecting lines, connect dots with line, draw a square, draw a circle, color without crossing lines, perform writing activities).
7- Removing and placing pellets (ask child to turn on the bottle with the affected hand and dump out the pellets, then put the pellets in the bottle with the affected hand).
8- Using clay of different colors (ask child to make different shapes by clay as ball, rope).
9- Use an effective lateral pinch grasp pattern by turning pages of a book with thick cover and thick pages (ask the child to open the book, and then turn pages with the affected hand).
10- Arranging 15 balls that are different in colors (1 blue, 2 orange, 3 yellow, 4 green, and 5 red balls) into five columns of different heights with the affected hand.
11- Arranging 5 cylindrical rings into one column starting from the biggest to the smallest one with the affected hand.
12- Putting on and removal of a larger pair of socks, then his or her own socks with the affected hand.
13- Using the scissor (ask the child to insert the thumb, the index together with the middle finger into the holes of a scissor, followed by opening and closing the scissor several times, cut a paper, cut on the line, cut out the circle along the line, cut out the square along the line).

Statistical Analysis

Data were analyzed both descriptively (Standard deviation (SD), Mean difference (MD)) and inferentially in this investigation.

Statistical analyses for parametric data were used to examine quantitative difference between groups using un-paired T-test. For non-parametric data, Mann-Whitney test was used to examine quantitative difference between groups, while Wilcoxon matched pairs test was utilized for comparing data within the groups (Snedecor et al., 1989).

RESULTS

Data shown in table (1) reveals that ages (mean ± standard deviation) of group A and group B were 60.0±6.459 and 62.467±5.89 months, respectively. Distribution of males and females in group A was 60% and 40%, respectively while it was 53.33% and 46.67% in group B, respectively. Moreover, data presented in table (1) revealed that the distribution of right side and left side affections in group A were 53.33% and 46.67%, respectively while in group B, they were 46.67% and 53.33%, respectively. Comparing mean values of the above mentioned three parameters for both groups revealed insignificant difference at ($P< 0.05$).

Table (1): Demographic characteristics of participant hemiplegic children.

Group	Age (months)	Gender				Affected Side			
		X±SD				X±SD			
	X±SD	Male		Female		Right		Left	
		No.	%	No.	%	No.	%	No.	%
Group A	60.0±6.459	9	60	6	40	8	53.33	7	46.67
Group B	62.467±5.89	8	53.33	7	46.67	7	46.67	8	53.33

Table (2) compares pre treatment mean values ± SD of groups (A) and (B). The mean values ± SD of age equivalent for grasping recorded 24.6±6.367 and 20.933±9.42 months for groups (A) and (B), respectively; which indicated insignificant differences at ($P< 0.05$). The obtained mean values ± SD of age equivalent for visual motor integration were 26.333±8.209 and 21.267±4.543 months for both groups, respectively; which also indicated insignificant differences at ($P < 0.05$). The mean values ± SD of fine motor quotient were shown to be 62.8±11.718 and 57.2±3.299 for both groups (A) and (B), respectively; which again indicated insignificant differences at ($P< 0.05$).

Table (2): Comparison between pre-treatment mean values of age equivalent for grasping and visual motor integration (months) and fine motor quotient in groups (A) and (B).

Item	Age Equivalent for Grasping		Age Equivalent for Visual Motor Integration		Fine Motor Quotient	
	X±SD	MD	X±SD	MD	X±SD	MD
Group A	24.6±6.367	3.867 (NS)	26.333±8.209	5.066 (NS)	62.8±11.718	5.6 (NS)
Group B	20.933±9.42		21.267±4.543		57.2±3.299	
u value	89.5		69.0		85.0	
P value	0.3505		0.0745		0.2713	

X: mean SD: Standard Deviation MD: Mean difference
P value: Probability value u value: Mann-Whitney test value NS: Non significant

Data presented in table (3) showed that pre and post treatment mean values ± SD of age equivalent for grasping were 24.6±6.367 and 29.467±8.236 months, respectively; those of age equivalent for visual motor integration were 26.333±8.209 and 33.133±9.731 months, respectively; and those of fine motor quotient were 62.8±11.718 and 67.4±12.569, respectively.

Differences between the pre and post treatment mean values of age equivalent for grasping, and for visual motor integration as well as the fine motor quotient were statistically significant at ($P< 0.05$). The percentages of post treatment improvements were 19.78%, 25.8% and 7.32, respectively.

Table (3): Comparison between pre- and post-treatment mean values of age equivalent for grasping and visual motor integration (months) and fine motor quotient in group (A).

Item	Age Equivalent for Grasping			Age Equivalent for Visual Motor Integration			Fine Motor Quotient		
	X±SD	MD	Change (%)	X±SD	MD	Change (%)	X±SD	MD	Change (%)
Pre-treatment	24.6±6.367	4.867 (S)	19.78	26.333±8.209	6.8 (S)	25.8	62.8±11.718	4.6 (S)	7.32
Post-treatment	29.467±8.236			33.133±9.731			67.4±12.569		
W value	105			120			91		
P value	0.001			0.001			0.0002		

X: mean SD: Standard Deviation MD: Mean difference
P value: Probability value W value: Wilcoxon matched pairs test value
S: Significant %: Percentage of change

Data presented in table (4) showed that pre and post treatment mean values ± SD of age equivalent for grasping were 20.933±9.422 and 49.467±8.262 months, respectively; those values of age equivalent for visual motor integration were 21.267±4.543 and 52.267±8.293 months, respectively; and that the mean values of fine motor quotient were 57.2±3.299 and 87.2±8.9362, respectively.

The mean differences of the three parameters (28.533, 31.0 and 30.0, respectively) were statistically significant at ($P<0.05$). The percentages of post-treatment improvements recorded were as high as 136.31%, 145.77%, and 52.45% for each of the assayed parameters, respectively.

Table (4): Comparison between pre- and post-treatment mean values of age equivalent for grasping and visual motor integration (months) and fine motor quotient in group (B).

Item	Age Equivalent for Grasping			Age Equivalent for Visual Motor Integration			Fine Motor Quotient		
	X±SD	MD	Change (%)	X±SD	MD	Change (%)	X±SD	MD	Change (%)
Pre-treatment	20.933±9.422	28.533 (S)	136.31	21.267±4.543	31.0 (S)	145.76	57.2±3.299	30.0 (S)	52.45
Post-treatment	49.467±8.262			52.267±8.293			87.2±8.936		
W value	120			120			120		
P value	0.0001			0.0001			0.0001		

X: mean SD: Standard Deviation MD: Mean difference
P value: Probability value W value: Wilcoxon matched pairs test value
S: Significant %: Percentage of change

Table (5) illustrates post-treatment mean values of age equivalent for grasping and age equivalent for visual motor integration as well as fine motor quotient for both groups (A and B). Such values were 29.467±8.236 and 49.467±8.262 months (age equivalent for grasping), respectively; 33.133±9.731 and 52.267±8.293 months (age equivalent for visual motor integration), respectively; and 67.4±12.569 and 87.2±8.962 for fine motor quotient, respectively.

The differences between the control and study groups in their post-treatment mean values; regarding age equivalent for grasping, age equivalent for visual motor integration and fine motor quotient were significant at ($P<0.05$) and the percentages of changes recorded were 67.87%, 57.75% and 29.38% in favor of study group (B).

Table (5): Comparison between post-treatment mean values of age equivalent for grasping and visual motor integration (months) and fine motor quotient in both groups (A and B).

<table>
<tr><th rowspan="2">Item</th><th colspan="3">Age Equivalent for Grasping</th><th colspan="3">Age Equivalent for Visual Motor Integration</th><th colspan="3">Fine Motor Quotient</th></tr>
<tr><th>X±SD</th><th>MD</th><th>Change (%)</th><th>X±SD</th><th>MD</th><th>Change (%)</th><th>X±SD</th><th>MD</th><th>Change (%)</th></tr>
<tr><td>Pre-treatment</td><td>29.467±8.236</td><td rowspan="4">20.0 (S)</td><td rowspan="4">67.87</td><td>33.133±9.731</td><td rowspan="4">19.134 (S)</td><td rowspan="4">57.75</td><td>67.4±12.569</td><td rowspan="4">19.8 (S)</td><td rowspan="4">29.38</td></tr>
<tr><td>Post-treatment</td><td>49.467±8.262</td><td>52.267±8.293</td><td>87.2±8.962</td></tr>
<tr><td>W value</td><td>6.5</td><td>9.0</td><td>21.0</td></tr>
<tr><td>P value</td><td>0.001</td><td>0.0001</td><td>0.0002</td></tr>
</table>

X: mean SD: Standard Deviation MD: Mean difference
P value: Probability value u value: Mann-Whitney test value
S: Significant %: Percentage of change

DISCUSSION

The present study was conducted to determine the effect of Spandex dynamic splint on hand functions of hemiplegic children.

Choosing the age of the children representing the study sample to be from four to six years comes in agreement with Exner (2005) who reported that at age of three years; most children with typical development acquire the ability to use a power grasp, cylindrical grasp, and spherical grasp with control.

Data of our results revealed no significant difference when comparing the pre-treatment mean values of age equivalent for grasping and for visual motor integration as well as fine motor quotient of groups (A) and (B). This fact indicates the homogeneity of the two groups before starting the study and hence reflects the validity of sample collection and random classification of children among the two groups.

The hemiplegic children showed lower scores in Peabody Developmental Motor Scale (PDMS) assessing their fine motor skills (grasping and visual motor integration) and fine motor quotient than the predicted scores corresponding to their real age, which might be attributed to that the skills of independent finger movements doesn't develop normally, and also may be due to abnormal muscle tone. These explanations are in agreement with Yekutiel et al. (1994) who reported that during tasks requiring fine manipulation, children with cerebral palsy often employ several fingers making moving slow and clumsy.

Another explanation of the previous result (lower PDMS scores of hemiplegic children) may be ascribed to the mirror movements; which are defined as "involuntary and unnecessary movements". These movements frequently involve the distal upper limbs during repetitive or alternating finger or hand movements. This explanation comes in agreement with Espay et al. (2006) who reported that mirror movements have been recognized in a variety of neurological disorders, such as hemiplegic cerebral palsy in children.

In this study, our results indicate there was an improvement in post-treatment in groups (A) and (B). But there was a big difference in the degree of improvement for grasping and visual motor integration plus the fine motor quotient in group (B) who received the traditional physical therapy program and specially designed program for facilitation of hand function while wearing Spandex dynamic splint compared with the improvement in group (A) who received the same traditional physical therapy program and specially designed program for facilitation of hand function without wearing Spandex dynamic splint. This showed the real effect of Spandex dynamic splint.

The effect of Spandex dynamic splint was evident in the results obtained. The post-treatment mean values of age equivalent for grasping, age equivalent for visual motor integration and fine motor quotient in group (B) showed statistically significant differences, recording improvement percentages equal to 136.31%, 145.77% and 52.45%, respectively. Such improvements might occur as a result of the use of Spandex dynamic splint. These findings could be explained by the fact that dynamic splints including Spandex dynamic splint, are a type of orthotics that provide support, control, and at the same time, allow and guide the wearer's movements. This explanation comes in agreement with the findings of Blair et al., (1995) who stated that Spandex dynamic splint has reportedly been useful in controlling abnormal tone, stabilizing posture, and improving the functional abilities of spastic hemiplegic children.

On the other hand, Spandex dynamic splint applies prolonged, low-load (gentle) forces to the musculoskeletal system to produce changes in muscle recruitment strategies. Such flexible compression and stabilizing orthotic provides sensory input and hence is useful in improving the motor control of an individual suffering from a neurological disorder.

Spandex dynamic splint also provides optimum alignment essential for hand function, which is accomplished by wrapping the torso in a Velcro-sensitive garment that serves as a strapping allowing the child to attach straps that work like external muscles to improve optimum alignment and stability. This opinion is supported by Blair et al. (1995) who stated that the use of flexible compression bracing in children with neuromotor deficits improved the possibilities for stability and movement control without severely limiting joint movement options.

The objectives of using Spandex dynamic splint for hemiplegic children in the present study are to prevent deformities, correct soft tissue contractures, control undesirable motions of affected parts, protect the weak stabilizing muscles, control deviations associated with tonus abnormality and to enhance experience of the child who suffers delay in both gross and fine motor skills. So, as Spandex dynamic splint wearing was added to the rehabilitation program, it was noted that there was more coordination and control in movements which lead to more perfect execution of hand skills. This implies that Spandex dynamic splint can maximize functional hand use.

Regarding the results of grasping and visual motor integration, there were highly significant improvements of grasping and visual motor integration of the hemiplegic children in group (B) more than group (A). This finding could be attributed to that the use of Spandex dynamic splint supports and maintains joint position, which includes assisting in reducing forearm pronation, maintaining wrist in neutral position and increasing stability which lead to more perfect execution of hand skills. In addition to the use of Spandex dynamic splint, the children received specially designed program for facilitation of hand functions which enhance further improvement of hand functions skills.

These results agree with those declared by Cook and Woollacot (2007) who stated that normal upper extremity functions including the ability to reach, grasp and manipulate objects, are the basis for fine motor skills which are important for the activities of daily living such as feeding, dressing, grooming and handwriting. The authors reported that the upper extremity control is intertwined with both fine and gross motor skills. Thus, recovery of the upper extremity function is an important aspect of retraining the patient for most areas of rehabilitation including both occupational and physical therapy.

Conclusion

From the above mentioned details and according to the reports of the investigators in the fields related to the present study, it can be concluded that the additive use and effect of Spandex dynamic splint imposed significant improvements on hand functions in hemiplegic children as long as the treatment was conducted for successive three months. Such improvement was much more pronounced than the improvement obtained when those children were subjected merely to specially designed physical therapy program for facilitation of hand functions.

From the obtained results of the study, it can be concluded that, Spandex dynamic splint could be used in addition to traditional physical therapy program and occupational therapy program to improve hand functions of affected upper limbs in spastic hemiplegic children.

REFERENCES

1- Blair, E., Ballantyne, J., Horsman, S. and Chauvel, P.A.: A study of dynamic proximal stability splints in the management of children with cerebral palsy. Dev. Med. Child Nurol., 37: 544-554, 1995.

2- Cook, A.S. and Woolacott, M.H.: Abnormal upper extremity manipulation control. In Moto Control: Translating Research into Clinical Practice, 3rd ed., Lippincott Williams and Wilkins, 2007.

3- Duff, S., Cook, A. and Woollcott, M.H.: Clinical management of the patient with reach, grasp and manipulation disorders. In: Cook, A. and Woollacott, M.H. Motor Control, Theory and Practical Applications. 2nd ed., LippinCott, Williams and Wilkins Co. 2001.

4- Embry, D.G.: Efficacy studies in children with cerebral palsy; Focus on upper extremity function. Phys. Occupat. Therapy Pediatr., 12(4): 89-95, 1998.

5- Espay, A.J., Li, J.K., Jhonston, L., Chen, R. and Lang, A.E.: Mirror movementsin parkinsonism: evaluation of a new clinical sign. J. Neurol. Neuroserg. Psychiatry, 76: 1355-1359, 2006.

6- Exner, C.E.: Development of hand skills. In: Case-Smith J. ed., Occupational therapy for children. Mosby, st. Louis, USA, 347-350, 2005.

7- Folio, M.R. and Fewell, R.R.: Peabody Developmental motor scale. 2nd ed., Austin, pro. Ed. An International Publisher, 2002.

8- Gromly, M.E.: Treatment of neuromuscular and musculoskeletal problems in cerebral palsy. Pediat. Rehabil. 4(1): 5-6, 2001.

9- Knox, V.: The use of Lycra garments in children with cerebral palsy: A report of a descriptive clinical trial. British J Occupational Therapy, 66(2): 71-77, 2003.

10- Lukhan, M.B., Rosales, R.L. and Dressler, D.: Effectiveness of botulinum toxin A for upper and lower limb spasticity in children with cerebral palsy: a summary of evidence: review. J. Neural. Transm. 116: 319-331, 2009.

11- Nicholson, J.H., Morton, R.E., Attfield, S. and Rennie, D.: Assessment of upper limb function and movement in children with cerebral palsy wearing Lycra garments. Dev. Med. Child Nurol. 43: 384-391, 2001.

12- Rosenbaum, P.L., Walter, S.D., Hanna, S.E., Plisano, R.J., Russell, D.J., Raina, P., Wood, E., Bartlett, D.J. and Galuppi, B.E.: Development and reliability of a system to classify gross motor function in children with cerebral palsy. J. Amer. Med. Assoc., 288: 1357-1363, 2002.

13- Snedecor, G., Cochran, W. and Cox, D.: Statistical Methods (8th edition). The Iowa State University Press, 1989.

14- Yekutiel, M., Jariwala, M. and Stretch, P.: Sensory defects in the hand of children with cerebral palsy: a new look at prevalence. Dev. Med. Child Neurol. 36: 619-624, 1994.

الملخص العربي