Original Article

EFFICACY OF POSTURAL CORRECTION SUIT ON GAIT PARAMETERS AND EXECUTIVE MOBILITY ACTIVITIES IN DIPLEGIC CHILDREN

Mohamed Ali Elshafey

Lecturer of Physical Therapy, Department of Physical Therapy for Growth and Developmental disorder in Children and its Surgery, Faculty of Physical Therapy, Cairo University.

ABSTRACT

Background: Spastic diplegic children walk with abnormal gait pattern, suit therapy used for treatment and rehabilitation of diplegic children as it improved gross motor development and corrected abnormal posture via its elastic strapping system, but there was no suit designed especially for postural correction.

Purpose: The purpose of the current study was to investigate the efficacy of the postural correction suit on gait parameters and executive mobility activities in diplegic children.

Materials and methods: Thirty ambulant spastic diplegic children, their age ranges from four to six years old participated in this study. They were randomly divided into two matched groups (control and study). The control group received a selected postural correction program includes, stretching exercises, strengthening exercises, balance exercises and posture and gait correction exercises, while the study group received the same selected postural correction program with the postural correction suit. All children received the treatment for two hours, three times weekly for three successive months. Kinematic gait parameter (hip, knee, and ankle joints angular displacement during mid stance phase) were evaluated by 3D gait analysis. Executive mobility activities at home were evaluated by MobQues28.

Results: There was a significant improvement in all measured variables for both groups in favor of the study group.

Conclusion: The postural correction suit through its elastic strapping system allows the child's body to be aligned as close to normal as possible. This restoration of the posture and proper function of postural muscles allowed the patients to learn proper patterns of movement thus improving gait patterns and excutive mobility activities in diplegic children.

Brief summary: postural correction suit used to treat crouch gait pattern of spastic diplegic children, kinematic gait parameters and executive nobilities activities were measured for both groups, the result showed significant improvement for postural correction suit.

KEYWORDS: Postural Disorders, Crouch Gait, Suit Therapy, Gait Analysis, MobQues28

Address for correspondence: Mohamed Ali Elshafey, Lecturer of Physical Therapy, Department of Physical Therapy for Growth and Developmental disorder in Children and its Surgery, Faculty of Physical Therapy, Cairo University. Phone No. 00201225897151. **E-Mail:** elrahmapt@gmail.com

Access this Article online

Quick Response code

International Journal of Physiotherapy and Research
ISSN 2321- 1822
www.ijmhr.org/ijpr.html

Received: 07-02-2014 Accepted: 25-02-2014
Peer Review: 07-02-2014 Published: 11-06-2014

BACKGROUND

Spastic diplegia is the most common pattern of motor impairment in patients with cerebral palsy (CP) due to a number of deficits, including poor muscle control, weakness, impaired balance and spasticity [1]. Spastic diplegic children typically walk slowly and have difficulty in performing activities such as walking up and down steps or running. [2]

According to kinematics gait analysis there are four types of spastic diplegic gait pattern 1- True equines: the ankle is in equines and the knee and hip are in extension; 2- Jumping gait: at initial contact the hip and knee are excessively flexed and the ankle is in plantar flexion, and during mid- stance, the hip and knee extend and the center of gravity moves upward to an excessive degree as the child is jumping; 3- Apparent equines: the child walks on toes only because of excessive flexion at the knee and hip, equines are apparent, but not real; 4- Crouch gait: the ankle is in calcaneus and the hip and knee are very flexed. [3]

Crouch gait is the most resistant condition to treat in spastic diplegic children. Crouch gait complex consists of flexion at hip and knee and planter flexion at ankle [4]. Spastic diplegic child usually stands on the toes, preventing proper weight bearing on the heels due to increased muscle tone in the calf muscles [5]. Kinematics gait analysis for crouch gait pattern shows the effects of exaggerated knee flexion and the requirement of increased dorsiflexion of the ankle. Extensive arm swinging and increased vertical trunk displacement are seen, and knee torque is more than six times the value recorded for normal extension moment occurring during the gait cycle. [6]

Depending on the predominant type of spasticity, the pelvis is tilted anteriorly (hip flexor spasticity) or posteriorly (hamstring spasticity), combined with spasticity of the hip adductors, quadriceps, calf muscle. This will leads to mal-alignment of all lower extremity joints. Adduction and inward rotation of the leg with flexor deformities of the hips and knees result in the typical scissors posture with an equino-varus or valgus deformity of the feet. Equinus feet may be related to inability to bring, the weight forward over the base of the heel, using the anterior tibial group, so lurching forward by the planter flexors is seen. [7]

Suit therapy has been proposed as an alternative to conventional therapy to treat the postural disorders associated with CP [8]. The suit is a soft dynamic proprioceptive orthotic device, combination of suit therapy with intensive physiotherapy in rehabilitation of CP children may sufficiently reduce the functional limitation in these children. [9]

Suit therapy improved motor function and posture [10], improved vertical stability [11], normalized of EEG signal [12]. suit therapy improves vertical postural stability in CP children, provides support for weak muscles. As the patient progresses the bands are tightened up and provide resistance, which leads to gains in strength through the loading effects of the elastic bands. [13] Wearing the therapeutic suit while performing the physical therapy program result in increased range of motion and improved the standing posture in children with CP [14]. Suit therapy increased the mechanical efficiency index during stair-climbing and reduced the metabolic cost of external work (8).Suit improved walking pattern and self-care activities in 70% of patients with residual stage infantile CP, These effects were demonstrated by electroencephalogram, electromyogram (EMG), studies of somatosensory evoked potentials, and studies of the vestibular system. [15]

This study included treatment of spastic diplegic children with the postural correction suit comparing its effect on gait parameters and executive mobility activities with the selected postural correction program.

MATERIALS AND METHODS

Study Design: This study was a randomized controlled trial, the procedures followed were in accordance with the ethical standards and after approval of the children families. The study performed over the period from October 2012 to may 2013.

Subjects: Thirty spastic diplegic CP children participated in this study. Their ages range from four to six years old. They were selected from the Outpatient Clinic of the Faculty of Physical Therapy, Cairo University. They were divided randomly into two matched groups, control group (9 males - 6 females) and study group (7 male- 8 female).

Inclusive criteria: All children were ambulant spastic diplegic children with crouch gait pattern, have grade I and II according to gross motor function classification system (GMFCS) and spasticity of grade1 and 1^+ according to modified ashworth scale. All children can follow orders and have neither auditory nor visual disorders.

Exclusive criteria: subjects were excluded if they had hip dislocation, structured scoliosis, fixed contractures or deformity, heart diseases and uncontrolled convulsions.

Materials: Motion analysis system with the Q trace software which consists of the following parts: camera system with six cameras for three dimensional gait analysis, a wand kit is used for calibration of system, an ACB - 530 serial interface adapter (a communication card which is mounted in the pc), APC computer with Q trace software installed and eight meters, long, wooden walk way. Twenty eight item version mobility questionnaire for ambulant children with CP (MobQues28): mobility questionnaire measures the difficulty in the execution of mobility activities of children with CP in the environment as rated by their parents [16]. The questionnaire composed of a rating scale on which the parents score the amount of difficulty their child experiences in the execution of mobility activities. The total score of the individual reflects the level of mobility limitation and may be useful in the evaluation of interventions acting on mobility limitations in children with CP [17]. Postural correction suits. It is a newly designed suit consists of lumbosacral belt with 10 cm width and twenty sites of strap attachment, two knees cuff and especially designed rubber strap with tensile strength of 40 Newton. The rubber strap were calibrated before each session by hooking one side and 18 kilogram weight attached to the other side maximum increase in strap length was 15% from the original strap length (elasticity constant = 2.4).

Methods for evaluation: Kinematic gait analysis by 3D motion analysis system: angular displacement of hip, knee and ankle during mid stance phase were measured for both groups before and after treatment. Preparing the system includes the following steps: a- Setup for the cameras and volume. b- Calibration of the 3D before capture was performed. c- Capture or measurement phase starts, including marker setup and entering subject data (name, age, weight and height) on computer software. The child asked to walk along the wooden walk. d- Export or transfer of the selected gait cycle of the evaluated patient for analysis and obtaining the desired data. e- Analysis and calculations were initiated with the run button. When the calculations are completed, the results were displayed showing the calculated global gait parameters.

The MobQues28: the mobility activities calculated by scoring 28 mobility activities by the parents for both groups before and after treatment. The scoring procedure response options of the MobQues 28 are: a- impossible without help (score 0), b-very difficult (score 1), c-somewhat difficult (score 2), d- slightly difficult (score 3), e- not difficult at all (score 4). Total scores are calculated by adding all item scores (range 0–4) divided by the maximum possible score and multiplied by 100 to obtain scores on a scale of 0 to 100 (with a low score representing severe limitations in mobility): MobQues 28 = (Σ item / 112) 100.

Methods for treatment: The control group received the selected physical therapy program including, strengthening exercises, balance exercise, facilitation of postural mechanisms and reactions, postural correction exercises and stretching exercises. The study group received the same selected physical therapy program while wearing the postural correction suit. The child weared the lumbosacral belt and connected the straps to it, the anterior thigh strap attached from the lumbosacral belt to the knee cuff just below the knee joint to correct knee flexion, the leg strap attached from the knee cuff and wraps around the shoes to correct equines deformity. The posterior thigh strap attached from the lumbosacral belt to the knee cuff to tilt the pelvic posteriorly, and the spiral strap attached from the belt and wraps around the lower limbs to correct abnormal rotation and ends to the lumbosacral belt. The spine straps starts from the lumbosacral belt and wraps around the trunk to correct abnormal trunk posture and tilt the pelvis posteriorly and attached to the lumbosacral belt. Both groups received treatment for two hour per session three times weekly for three successive months.

Statistical analysis: Chi- squared was conducted to ensure equivalence of spasticity grades and GMFCS distribution between both groups. T-test was conducted to compare the differences between both groups pre and post treatment. Paired t test was conducted to compare between pre and post treatment measurements within each group. The level of significance for all statistical tests was set at $p < 0.05$. All statistical measures were performed through the statistical package for social studies (SPSS) version 19 for windows.

RESULTS

DEMOGRAPHIC CHARACTERISTICS:

Table 1 showed the mean ± SD of age, weight, and height of control and study groups. There was no significant difference between both groups in the mean age, weight, and height (p > 0.05). Patients in both groups had spasticity of grade 1 and grade 1+. As shown in table (2), there was no significant difference in the distribution of spasticity grades between both groups (p > 0.05). There was no significant difference in the distribution of GMFCS grades between study and control groups (p > 0.05). (table 2).

Table 1: Comparison between control and study groups in mean age, weight, and height:

Variables	Control	Study	t- value	p-value
	$\bar{X}$ ± SD	$\bar{X}$ ± SD		
Age	5.36 ± 0.74	5.43±0.7	-0.25	0.8*
Weight	20.2 ± 3.12	20.7±2.7	-0.25	0.8*
Height	113.5 ± 8.53	113.1±8.08	0.09	0.92*

$\bar{X}$ ± SD: mean ± standard deviation

p: level of significant *: non significant

Table 2: Comparison of the distribution of spasticity and GMFCS grades in both groups:

Variables		Study	Control	X² value	p-value
Spasticity	Grade 1	(8) 53. 3 %	(7) 46.7%	0.13	0.71*
	Grade 1+	(7) 46.7%	(8) 53.3 %		
GMFCS	I	(7) 46.7%	(7) 46.7%	0	1*
	II	(8) 53.3 %	(8) 53.3 %		

X²: Chi-squared value *: non significant

Comparison between pre treatment values of both groups: There was no significance difference between both groups in the measured variables pre treatment as illustrated in table (3)

Table 3: Comparison between pre treatment mean values for both groups:

Variables	$\bar{X}$ ±SD Control	study	p-value
MobQuest 28 (%)	76.12±3.45	75.41±4	0.6*
RT hip displacement	33.60±2.92	33.13±22	0.627*
LT hip displacement	34.33±3.65	32.93±26	0.237*
RT knee displacement	36.73±4.096	36.26±3.825	0.750*
LT knee displacement	36.73±3.71	36.0±3.545	0.584*
RT ankle displacement	32.06±2.548	32.53±3.85	0.699*
LT ankle displacement	32.6±2.164	32.53±3.20	0.947*

$\bar{X}$ ± SD: mean ± standard deviation

p: level of significant *: non significant

Comparison between pre and post treatment of both groups: Comparison between pre and post treatment values for both groups revealed that there was a significant increase in post treatment mean value of both group as illustrated in table (4).

Table 4: Comparison between pre and post treatment mean values parameters for both groups:

Variables	Control group $\bar{X}$ ±SD Pre	Post	P Value	Study group $\bar{X}$ ±SD Pre	post	P Value
MobQuest 28 (%)	76.12±3.4	77.9±3.26	0.0001**	75.41±4	80.75±3.4	0.0001**
RT hip displacement	33.60±2.9	30.46±2.64	0.0001**	33.13±22	25.73±2.43	0.0001**
LT hip displacement	34.33±3.6	31.13±3.1	0.0001**	32.93±26	25.53±2.06	0.0001**
RT knee displacement	36.73±4.09	32.73±3.6	0.0001**	36.26±3.82	27.8±3.3	0.0001**
LT knee displacement	36.73±3.7	32.93±3.6	0.0001**	36.0±3.54	27.6±2.9	0.0001**
RT ankle displacement	32.06±2.5	28.26±2.3	0.0001**	32.53±3.8	24.6±2.5	0.0001**
LT ankle displacement	32.6±2.16	28.46±2.2	0.0001**	32.5±3.2	24.6±2.16	0.0001**

$\bar{X}$ ±SD: mean ± standard deviation

p: level of significant **: significant

Comparison between post treatment of both groups: Comparison between control and study groups post treatment revealed that there was a significant increase in post treatment mean value of the study group as illustrated in table (5).

Table 5: Comparison between post treatment mean values for both groups:

Variables	$\bar{X}$ ± SD Control	study	p-value
MobQuest 28 (%)	77.91±3.26	80.75±3.41	0.0001**
RT hip displacement	30.46±2.64	25.73±2.433	0.0001**
LT hip displacement	31.13±3.159	25.53±2.065	0.0001**
RT knee displacement	32.73±3.614	27.8±3.29	0.0001**
LT knee displacement	32.93±3.614	27.6±2.96	0.0001**
RT ankle displacement	28.26±2.34	24.6±2.55	0.0001**
LT ankle displacement	28.46±2.19	24.6±2.164	0.0001**

$\bar{X}$ ± SD: mean ± standard deviation

p: level of significant **: significant

DISCUSSION

Diplegic children walk with adapted gait pattern due to combination of primary abnormalities and secondary compensatory mechanisms producing this abnormal kinetic pattern.

Fig. 1: Post treatment comparison between both groups in MobQuest 28.

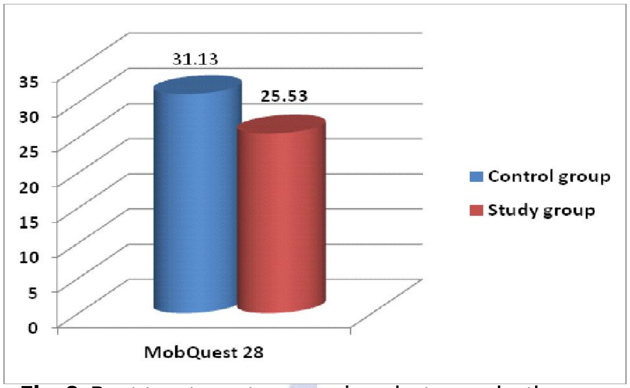


Fig. 2: Post treatment comparison between both groups in RT hip displacement.

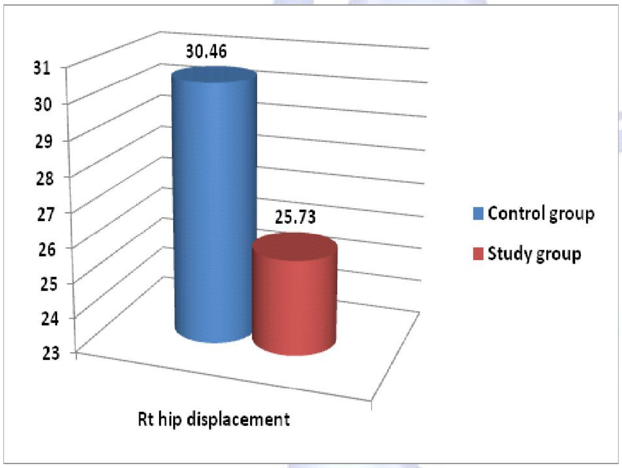


Fig. 3: Post treatment comparison between both groups in LT hip displacement.

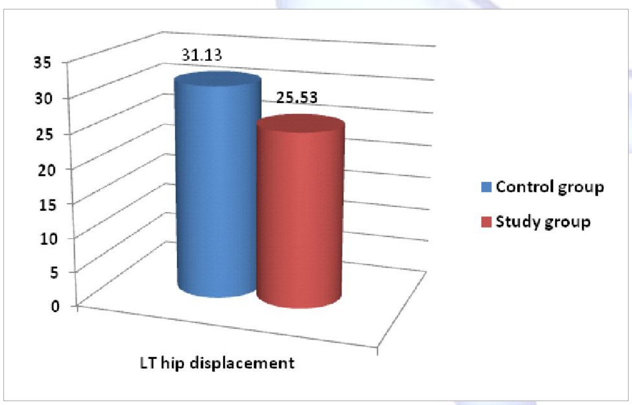


Fig. 4: Post treatment comparison between both groups in RT knee displacement.

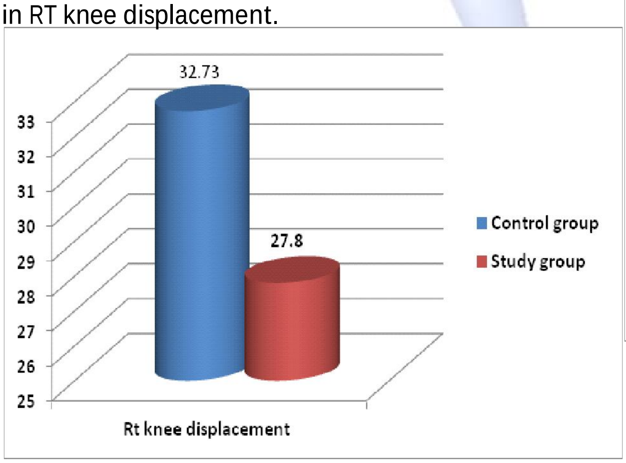


Fig. 5: Post treatment comparison between both groups in LT knee displacement.

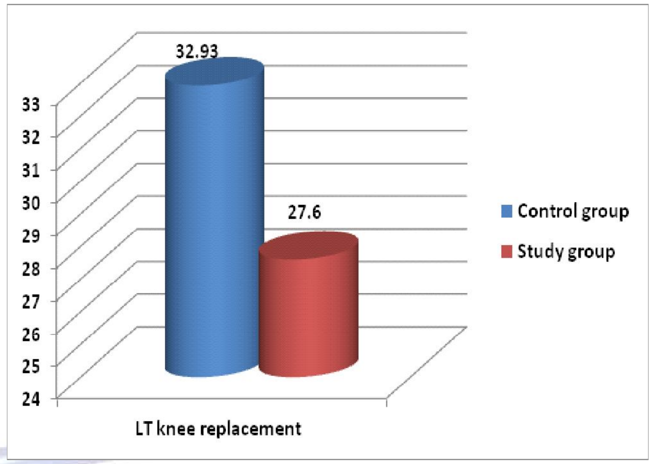


Fig. 6: Post treatment comparison between both groups in RT ankle displacement.

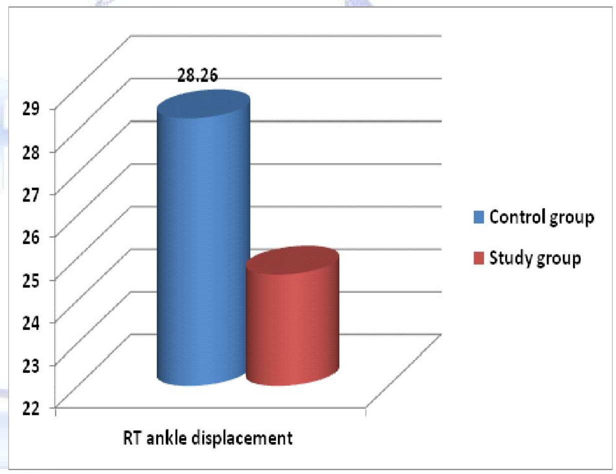
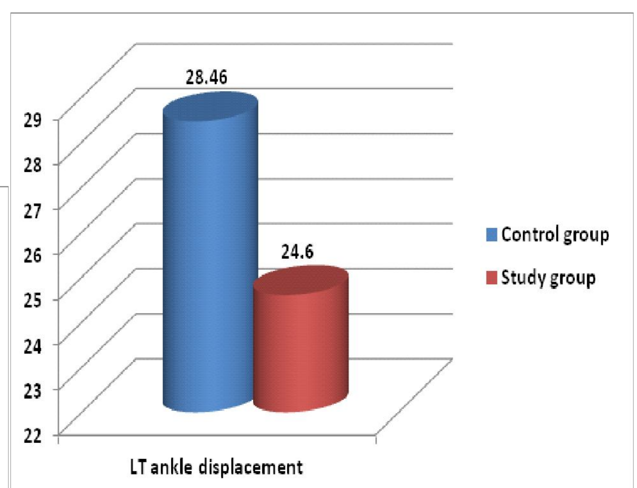


Fig. 7: Post treatment comparison between both groups in LT ankle displacement.



Damiano et al., [18] reported that spastic diplegic children suffers from increased muscle tone, loss of selective muscle control, deficient equilibrium reactions, and imbalance of muscle forces across the joints, particularly in the lower extremities resulting in abnormal gait pattern described as crouch gait.

The purpose of this study was to investigate the efficacy of postural correction suit on gait pattern and executive mobility activities in spastic diplegic children. Three dimension motion analysis is objective standardized method of evaluating spastic diplegic gait pattern. Quantitative gait analysis is useful in objective documentation of walking ability, as well as, identifying the underlying causes for walking abnormally in patients with CP. [19]

The MobQues 28 Used to determine functional limitation of spastic diplegic children and estimate functional improvements after application of the postural correction suit. The MobQues28 provides good measurement properties for measuring mobility limitation in ambulant children with CP, aged 4 to 13 years of age. [20]

The postural correction suit correct the abnormal gait pattern providing exoskeleton support the weak muscle groups and stretching the tight muscles placing the body segments in there neutral position. The anterior knee strap provides assistance to quadriceps muscle in extending knee joint. The posterior thigh strap assists hip extensors muscle. Balance between both straps keeps hip and knee joint in extension, overcome hamstring tightness and hip flexors tightness. The anterior leg strap assist anterior tibial group and stretch calf muscle correcting equines deformity and pronated feet. The rotatory straps correct abnormal internal rotation of lower limp and assist in dorsiflexion and knee extension, also help to overcome hip adductor tightness. Balance between trunk and thigh straps corrects the abnormal anterior pelvic tilt leading to correction of the lumbar lordosis. Trunk straps starts from the lumbosacral belt twisted on the trunk to assist weak back extensors muscles correct the abnormal forward postural together with posterior thigh straps, also can correct rounded shoulders.

Semenova [15] concluded that proprioceptive input produced by elastic rubber strap increases the patients' ability to form new motor plans, via reinforcement of appropriate movement pattern with repetitive exercise. Suit therapy would reduce pathological synergies, restore normal muscular synergies, and apply loads to antigravity musculature that would normalize the afferent vestibulo-proprioceptive input and improve postural control.

The suit provides a vertical load of 30 to 80 pounds of pressure giving proprioceptive input and improve the vestibular system [21]. Bar-Haim, et.al, [8] reported that elastic cords are adjusted by therapists to mimic normal flexor and extensor patterns of major muscle groups in an attempt to reposition limbs to correct abnormal posture. The theory is that once the body is in proper alignment, aggressive movement therapy can be performed that will re-educate the brain to recognize correct movement of the muscles.

The postural correction suit improves muscular strength and stretching for tight muscles the results of present study comes in agreement with Liptak [22] who reported that suit therapy allows controlled exercise against resistance as well as changes to posture. The postural correction suit provides strong exterocetors and proprioceptor stimulation by the pulling force of the straps that stimulates skin, muscles and joint receptors leading to correction of the abnormal gait pattern and postural deviations. Rosenbaum [23] stated that therapeutic suits assist in re-training the central nervous system by allowing the child to overcome increasingly complex pathological movement and to execute and repeat previously unknown movement patterns.

The postural correction suit enhances postural alignment, and plain movement activity of the child. Multiple repetitions of the correct movement assist in the development of new pathways within the nervous system and facilitate use of these proper movement patterns in the future.

CONCLUSION

The postural correction suit through its elastic strapping system aligns the child's body as close to normal as possible. This restoration of the posture and proper function of postural muscles allows the patients to learn proper patterns of movement thus improving gait pattern of diplegic children.

List of abbreviations:

CP - Cerebral palsy
MobQues28 - Twenty eight item version mobility questionnaire
EMG - Electromyography
SPSS - statistical package for social studies

Conflicts of Interest: Nil

Source of funding: Self funding.

Acknowledgement:

I am so sincere gratitude grateful to Dr. Rana Elmarzouki physiotherapist in Mit- Ghamer hospital for her participation in this study and support to complete this work, I am also grateful to all children who participated in this study.

REFERENCES

1. Blair E, Stanley F. Issues in the classification and epidemiology of cerebral palsy. Mental Retard Devel Disab Res Rev. 1997; 3:184-93.
2. Karen J. A randomized clinical trial of strength training in young people with cerebral palsy. Dev Med Child Neurol. 2003; 45:652-657.
3. Sutherland DH, Davids JR. Common gait abnormalities of the knee in cerebral palsy. Clin Orthop. 1993; 288:139-47.
4. Canale S. Beaty J. Campbell's Operative Orthopaedics. 12th ed. Mosby;2012.
5. Woollacott MH, Shumway-Cook A. Postural dysfunction during standing and walking in children with cerebral palsy: what are the underlying problems and what new therapies might improve balance? Neural Plast. 2005; 12(2-3):211-219
6. Perry J. Burnfield J. Gait Analysis: Normal and pathological function. McGraw-Hill, Inc; 1997.
7. McCarthy GT. Physical disability in childhood, an interdisciplinary approach to management. Edinburgh, Churchill Livingston; 1992.
8. Bar-Haim S, Harries N, Belokopytov M, Frank A, Copeliovitch L, Kaplanski J, Lahat E. Comparison of efficacy of Adeli suit and neurodevelopmental treatments in children with cerebral palsy. Dev Med Child Neuro. 2006; 48(5):325-330.
9. Seifeldin R, Noble C, Jackson A, Northrup J. The use of suit therapy in childhood cerebral palsy. A Pilot Study. Dev Med Child Neurol. 2004; 46:740-745.
10. Gracies JM. Pathophysiology of impairment in patients with spasticity and use of stretch as a treatment of spastic hypertonia. Phys Med Rehabil Clin N Am. 2001; 12:747-68.
11. Nemkova SA, Kobrin VI, Solobugov EG, Iavorskii AB, Sinel'nikova AN. Regulation of vertical posture in patients with children's cerebral paralysis treated with the method of proprioceptive correction. Aviakosm Ekolog Med. 2000; 34(6):40-46.
12. Sheinkman OG. The influence of the correction of motor disorders on the functional status of the brain in infantile CP. Zh Nevrol Psikhiatr Im S S Korsakova. 2000; 100 (3): 28-32.
13. Nemkova SA, Sologubov EG, Iavorski AB. New possibilities of the use of space technologies in the treatment of children with injuries of the central nervous system. Aviakosm Ekolog Med. 2002; 36(3): 55-8.
14. Gracies JM, Marosszeky JE, Renton R, Sandanam J, Gandevia SC, Burke D. Short-term effects of dynamic lycra splints on upper limb in hemiplegic patients. Arch Phys Med Rehabil. 2000; 81(12): 1547-1555.
15 Semenova KA. Basis for a method of dynamic proprioceptive correction in the restorative treatment of patients with residual stage infantile cerebral palsy. Neurosci BehavPhysiol. 1997; Nov-Dec27(6):639-43.
16. Van Ravesteyn NT, Dallmeijer AJ, Scholtes VA, Roorda LD, Becher JG. Measuring mobility limitations in children with cerebral palsy: interrater and intrarater reliability of a mobility questionnaire (MobQues). Dev Med Child Neurol. 2010; 52:194-199.
17. Van Ravesteyn NT, Scholtes VA, Becher JG, Roorda LD, Verschuren O, Dallmeijer AJ. Measuring mobility limitations in children with cerebral palsy: content and contruct validity of a mobility questionnaire (MobQues). Dev Med Child Neurol. 2010; 52: 229-235.
18. Damiano DL, Martellotta TL, Sullivan DJ, Granata KP, Abel MF. Muscle force production and functional performance in spastic cerebral palsy: Relationship of cocontraction. Arch Phys Med Rehabil. 2000; 81(7): 895-900.
19. Messier M. Biomechanical model of the human foot: kinematics and kinetics during the stance phase of walking. J Biomech. 2005; 26:1091-1104
20. Scholtes VA, Becher J, Roorda LD. Measuring mobility limitations in children with cerebral palsy: Rasch model fit of a mobility questionnaire, MobQues28. Arch Phys Med Rehabil. 2011; 92:640-645.
21. Turner A. The efficacy of Adeli suit treatment in children with cerebral palsy. Dev Med Child Neurol. 2006; 48:324.
22. Liptak GS. Complementary and alternative therapies for cerebral palsy. Ment Retard. Dev Disabil Res Rev. 2005; 11:156-63.
23. Rosenbaum P. Controversial treatment of spasticity: exploring alternative therapies for motor function in children with cerebral palsy. J Child Neurol. 2003;18:589-594.

How to cite this article: Mohamed Ali Elshafey. EFFICACY OF POSTURAL CORRECTION SUIT ON GAIT PARAMETERS AND EXECUTIVE MOBILITY ACTIVITIES IN DIPLEGIC CHILDREN.Int J Physiother Res 2014;2(3):495-501.