Role of Electrical Stimulation in Modulation of Balance in Children with Spastic Diplegia

Nahed S.Thabet
Department of Physical Therapy for Growth and Developmental Disorders in Children and its Surgery, Faculty of Physical Therapy, Cairo University, Egypt

ABSTRACT

Background and purpose: *Maintaining balance is a necessary requirement for all the activities of human performance. Most cerebral palsy children have deficits in balance, co-ordination, and gait throughout childhood and adulthood. Spastic diplegia is the most prevalent type of cerebral palsy; such children show a delay in the acquisition of various motor skills such as gross and fine motor functions. They often lack adequate stability due to impaired postural control and abnormal muscle tone. The present study was to evaluate the effects of twelve-week electrical stimulation for back and hip extensors muscles on standing balance in spastic diplegic cerebral palsy children.* ***Subjects:*** *Thirty children with spastic diplegia were selected from both sexes, ranging in age from six to eight years represented the sample of this study. They were divided randomly into two groups of equal number A (control) and B (study).* ***Procedures:*** *Evaluation before and after three months of treatment for each child of the two groups was conducted using Biodex stability system to evaluate standing balance. Group A received a selected exercise program, while group B received electrical stimulation program training in the form of high voltage pulsed galvanic stimulation in addition to the same exercise program given to group A.* ***Results:*** *The results revealed no significant differences in all the measured variables when comparing the pre-treatment results of the two groups, while significant improvement was observed in the two groups when comparing their pre and post-treatment mean values. Significant difference was also observed when comparing the post-treatment results of the two groups in favor of group B.* ***Discussion and conclusion:*** *Using electrical stimulation in treatment of children with spastic diplegic cerebral palsy has a significant effect in improving balance, which recommends its use in conjunction with different treatment procedures for children with spastic diplegic.*

Key words: *Diplegic cerebral palsy, Balance, electrical stimulation.*

INTRODUCTION

Cerebral palsy (CP) describes a group of disorders of posture and movement that occur as a result of a non-progressive disturbance in the developing fetal or infant brain[31]. The cerebral palsied children are characterized by abnormal muscle tone, posture reflexes and motor development. The classical symptoms are spasticity, involuntary movements, unsteady gait, and problems with balance[1]. Spastic diplegia is the most prevalent type of CP; it accounts for about 44% of the total incidence of CP and represents 80% of affected preterm infants[46]. Children with spastic diplegia have some motor impairment of their upper extremities as well as the lower extremities, although it is milder in the upper extremities than the lower one. Most children have significant weakness in the trunk. The primarily functional problem includes difficulty with mobility and posture. Other problems include postural deviations, and difficulty in movement transition[45].

Static and dynamic balance reactions of children with CP are poorer when compared with those of typically developed children .As balance skills are an integral part of gross motor abilities, poor balance causes difficulty with functional tasks involved in activities of daily living[25].

Difficulties in determining individual causes of balance impairment and disability are related to the diverse mechanisms involved; decreased muscle strength, range of movement, motor coordination, sensory organization, cognition, multisensory integration and abnormal muscle tone contribute to balance disturbances at different levels[8]. The impairment of balance while standing may be due to difficulty in activating and timing muscle contraction. This impairment may be compounded by muscle weakness secondary to inactivity. Reduced ability to balance while standing interferes with standing up, walking and stair climbing[43] Weakness in the spastic cerebral palsy has been recognized as clinical characteristic, from the perspective of this point, it is assumed that the standing balance or posture in these children might be improved with the strengthening of trunk muscles[7]. Coordinated activation of extensors and flexors of trunk as well as hip is required for well balanced posture[33].

Balance control is important for competence in the performance of most functional skills, helping children to recover from unexpected balance disturbances[44]. The treatment goals of spastic diplegic children focus on the prevention of disability by minimizing the effects of impairments, and maximizing the gross motor function. Achieving these goals involves promotion and maintenance of musculoskeletal integrity, prevention of deformities, and enhancement of optimal posture and movement to promote functional independence[27].

Neuromuscular electrical stimulation (NES) is a very popular way to improve the muscles efficiency and prevent muscle atrophy. Electrical stimulation (ES) has been a mainstay of physical therapy practice for many years as a method to rehabilitate patients that have sustained central nervous system impairment secondary to a stroke or spinal cord injury. There is a variety of electrical wave forms resulting in an electrical current that can be comfortably used to stimulate innervated muscles[6]. High voltage pulsed galvanic stimulation (HVPGS) is primarily used for activating the neuromuscular system through stimulation of intact lower motor neuron, to initiate contraction of paralyzed muscle and produce functional activities[26].

Therefore, the purpose of this study was to evaluate the effectiveness of electrical stimulation program training in the form of high voltage pulsed galvanic stimulation on standing balance in children with spastic diplegia who were unable to maintain balance.

SUBJECTS, INSTRUMENTATION AND PROCEDURES

Subjects

Thirty spastic diplegic CP children from both sexes participated in this study. They were selected from the pediatrics out-patient clinic, Faculty of Physical Therapy, Cairo University. Their ages ranged from 6 to 8 years. Children were randomly assigned into two groups of equal number (A and B), by asking each child to pick up an index card out of a box which contains 30 cards (15 card for each group) to determine which group he/she would be in. Group A (control), included 15 children (9 boys and 6 girls) with mean age of 6.9 ± 0.60 years, and they received the selected therapeutic exercise program. Group B (study) included 15 children (8 boys and 7 girls) with mean age of 6.92 ± 0.78 years. They received the same therapeutic exercise program which was given to the control group, in addition to ES for about 30 min every session, three times weekly, every other day for successive 3 months.

The subjects were selected according to the following criteria:

1. Spasticity grades ranged from 1 to 1+ according to modified Ashwarth scale[5].
2. All subjects were able to stand and walk.
3. All subjects did not have fixed deformity of both lower limbs.
4. Children were able to understand commands and follow instructions given to them in both testing and training sessions.
5. All subjects did not have visual or auditory defects.

Participants came to the evaluation laboratory where the Biodex balance system exit. Procedures took place twice; pre and post study period. Evaluation was conducted for each child of two groups by measuring of standing dynamic balance.

Instrumentation

I.) For evaluation

<u>1- Modified Ashwarth scale:</u>

Adapted from Bohannon and Smith, 1987[5]. It used to measure the degree of spasticity by passive movement.

2- Biodex Balance System:

It is a dynamic postural control assessment and training system (Biodex medical system, Shirley, New York). It consists of a movable balance platform which can be set at variable degrees of instability and safety support rails. This system is interfaced with computer software monitored through the control panel screen. During postural stability testing, the patient's ability to control the platform's angle of tilt is quantified as a variance from center. A large variance is indicative of poor neuromuscular control. When the system is on, the first displayed screen will show the main menu to choose testing. Determine the test parameters including test duration, weight, height of child, and the stability level was chosen.

3- Weight and height scale:

A valid and reliable weight and height scales were used.

II.)For treatment

1- Physical therapy tools of different shapes in the form of: Mats, wedges, rolls, medical balls, tilting board, wooden blocks, standing bar, parallel bars, stepper, and large mirror were used in conducting the exercise program.

2- Electrical stimulator was used for stimulation of back muscles and hip extensors; in the form of High voltage pulsed galvanic current type. The parameters were set as follows: Pulse frequency: 80 PPS (pulse per second). Ramp: 2 seconds. Cycle time: pulsed[2]. Treatment time: 30 minutes. Intensity: the intensity was then raised slowly until palpable contraction was felt and also depends on the child's tolerance.

Procedures

I.) For evaluation

All parents had been informed of all study procedures and objectives for their children with the absence of any risk. After signing a written consent form, instructions about evaluative procedures were explained for each child before the testing session to make sure that all children understood the steps of evaluation and familiar with the device. Evaluation for each child in the two groups was conducted in a warm and quite room before and after three months of treatment.

Test session

Test procedure, each subject was given a brief orientation and practice session to familiarize the patient with the equipment and the test protocol.

Biodex stability system was used to assess balance and postural stability. Each child in the two groups was asked to stand on the center of locked platform within the device with two legs stance while grasping the handrails, the display screen was adjusted so that each participant can look straight at it. At first, certain parameters were fed to the device.

(1) Child’s weight, height and age.

(2) Stability level (platform firmness).

Each child was then asked to achieve a centered position in a slightly unstable platform by shifting his/her feet position until it was easy to keep the cursor (representing the center of the platform) centered on the screen grid while standing in comfortable upright position. Once the participant was centered, the cursor was in the center of the display target, he/ she were asked to maintain his/her feet position till the platform was stabilized. Heels coordinates and feet angles from the platform were recorded as follows: heels coordinates were measured from the center of the back of the heel, and foot angle was determined by finding a parallel line on the platform to the center line of the foot.

The test began after introducing feet angles and heels coordinates into the Biodex system. The platform advanced to an unstable state, then the child was instructed to focus on the visual feedback screen directly in front of him with both arms at the side of the body without grasping handrails and attempting to maintain the cursor in the middle of the screen. Duration of the test was 30 s for each participant and the mean of three repetitions was determined. A print out was obtained at the end of each test including overall stability index, antero-posterior(A/P) stability index, and medio-lateral (M/L) stability index. The high values mean that the child had balance difficulty. This test procedure was carried out for each child in the two groups before and after three months of treatment programs.

Overall stability index: Represents the child's ability to control his balance in all directions.

Antero-posterior index: Represents the child's ability to control his balance from front to back directions. Medio-lateral index: Represent the child's ability to control his balance from side to side.

II.) For treatment

Treatment protocol:

The two groups attended one hour, three times/week for 12-weeks training program which included supervised exercise sessions.

For the control group:

- Facilitation of trunk control to improve postural control from different positions (prone, supine, sitting).
- Facilitation of righting, protective and equilibrium reactions: These exercises were carried through tilting from different positions (forward, backward, and sideways) in order to improve postural mechanisms via variety of exercises applied on medical ball and tilting board.
- Balance training was carried from different positions (quadruped, kneeling, half kneeling and standing) on tilting board.
- Squatting to standing exercise.
- Standing on one limb then standing on the other, manual standing with step forward and step backward grasping the child around both knees using standing bar, wooden blocks.
- Stooping and recovery exercising from standing position.
- Gait training activities between the parallel bars using stepper, large mirror were used in front of child. Also training on different floor surfaces (spongy and hard surfaces) on mat, on the floor.
- Strengthening exercises to weak muscles like back, hip, knee extensors.
- Stretching exercises for tight muscles like hip flexors, hamstrings and calf muscles in lower limb and for wrist flexors, pronators and elbow flexors in upper limb.

For the study group:

All the exercises given for the control group in addition to using the HVPGS as follows:

Preparation of the child for the session:

- The therapist explained to the child and his parents the rational for the treatment and emphasizing its harmless effect.
- The child was placed in prone lying position on a plinth with uncovered trunk.
- The child's back was cleaned using a piece of cotton and alcohol.
- The two electrodes were placed at erector spinae on each side muscle at level of mid dorsal region with 6cm apart for back muscles stimulation and gluteus maximus muscle one electrode over the saddle shaped area and the other over the iliac notch bilaterally for hip extensors stimulation.

Operating the stimulation unit:

- The apparatus was switched on. High voltage pulsed galvanic current type was chosen.
- Parameters were set as follows.
- Pulse frequency: 40 pulse per second.
- Ramp: 2 seconds.
- Cycle time: pulsed[2].
- Treatment time: 30 minutes.
- Intensity: the intensity was then raised slowly until palpable contraction was felt.
- After completion of the treating session, turn off the apparatus.
- Remove the electrodes and clean their sites on the child skin.
- Keep the apparatus out of the reach of children.

The study group attended three times/week for 12-weeks. The number and duration of training sessions used in our study were similar to training regimens used in previous electrical stimulation studies[42].

RESULTS

The collected data from this study represent the statistical analysis of the stability indices (SI) including overall stability index, antero-posterior stability index and medio-lateral stability index of the dynamic balance test at the level 8 stability (more stable platform) was measured before and after three months of treatment for the two groups. The raw data of the measured variables for the two groups were statistically treated to show the mean and standard deviation. Student t-test was then applied to examine the significance of the treatment conducted for each group.

1- Comparison between pre-treatment mean values of overall stability index for both control and study groups.

The mean values ±SD were 3.226 ±0.377 and 3.133± 0.404 degrees for both control and study groups respectively which indicated no significant difference (P >0.05) as shown in Table 1.

Table (1): Pre-treatment mean values of overall stability index for both groups (control and study).

Overall stability index	Pre treatment	
	Control group	Study group
Mean	3.226	3.133
±SD	±0.377	±0.404
t-Test	0.654	
P-value	0.519	
Significance	NS	

SD: standard deviation, P value: level of Significance, NS: non-significant.

2- Comparison between post-treatment mean values of overall stability index for both control and study groups.

The mean values ± SD were 2.626 ± 0.433 and 2.180± 0.466degrees for control and study groups respectively, significant difference was observed when comparing the post-treatment results of the two groups in favor of the study group as shown in Table 2 and Fig. 1.

Table (2): Post-treatment mean values of overall stability index for both groups (control and study).

Overall stability index	Post treatment	
	Control group	Study group
Mean	2.626	2.180
±SD	±0.433	±0.466
t-Test	2.718	
P-value	0.011	
Significance	S	

SD: standard deviation, P value: level of Significance, S: significant.

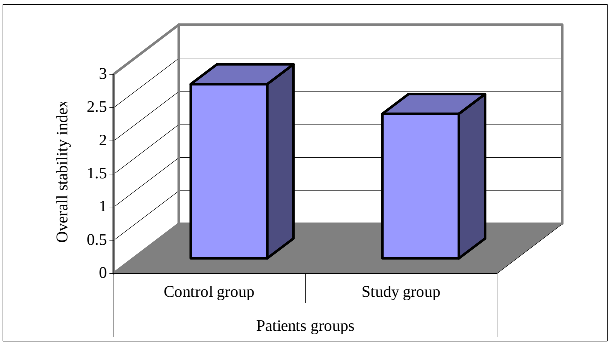

Fig. (1): Demonstrating the Post-treatment mean values of overall stability index for both groups.

3- Comparison between pre-treatment mean values of antero-posterior stability index for both control and study groups.

The mean values ± SD were 2.733± 0.441 and 2.686± 0.430 degrees for both control and the study groups respectively which indicated no significant difference (P >0.05) as shown in Table 3.

Table (3): Pre-treatment mean values of antero-posterior stability index for both groups (control and study).

Antero-posterior stability index	Pre treatment	
	Control group	Study group
Mean	2.733	2.686
±SD	±0.441	±0.430
t-Test	0.293	
P-value	0.772	
Significance	NS	

SD: standard deviation, P value: level of Significance, NS: non-significant.

4- Comparison between post-treatment mean values of antero-posterior stability index for both control and study groups.

The mean values ± SD were 2.246 ± 0.309 and 1.853± 0.456 degrees for control and study groups respectively, significant difference was observed when comparing the post-treatment results of the two groups in favor of the study group as shown in Table 4 and Fig. 2.

Table (4): Post-treatment mean values of antero-posterior stability index for both groups (control and study).

Antero-posterior stability index	Post treatment	
	Control group	Study group
Mean	2.246	1.853
±SD	±0.309	±0. 456
t-Test	2.763	
P-value	0.010	
Significance	S	

SD: standard deviation, P value: level of Significance, S: significant.

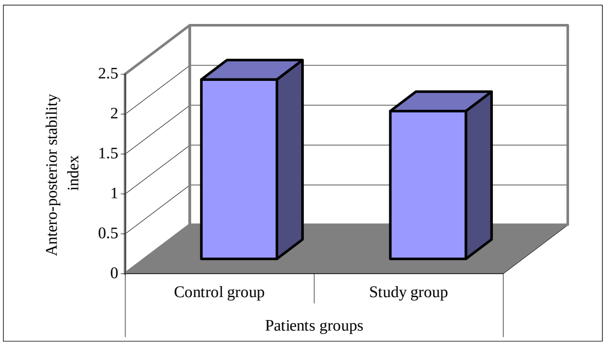

Fig. (2): Demonstrating the Post-treatment mean values of antero-posterior stability index for both groups.

5- Comparison between pre-treatment mean values of medio-lateral stability index for both control and study groups.

The mean values ± SD were 2.333± 0.479 and 2.246± 0.524 degrees for both control and the study groups respectively which indicated no significant difference (P >0.05) as shown in Table 5.

Table (5): Pre-treatment mean values of medio-lateral stability index for both groups (control and study).

Medio-lateral stability index	Pre treatment	
	Control group	Study group
Mean	2.333	2.246
±SD	±0.479	±0.524
t-Test	0.472	
P-value	0.640	
Significance	NS	

SD: standard deviation, P value: level of Significance, NS: non-significant.

6- Comparison between post-treatment mean values of medio-lateral stability index for both control and study groups.

The mean values ± SD were 1.966 ± 0.463and 1.566± 0.499degrees for control and study groups respectively, significant difference was observed when comparing the post-treatment results of the two groups in favor of the study group as shown in Table 6 and Fig. 3.

Table (6): Post-treatment mean values of medio-lateral stability index for both groups (control and study).

Medio-lateral stability index	Post treatment	
	Control group	Study group
Mean	1.966	1.566
±SD	±0.463	±0.499
t-Test	2.72	
P-value	0.031	
Significance	S	

SD: standard deviation, P value: level of Significance, S: significant.

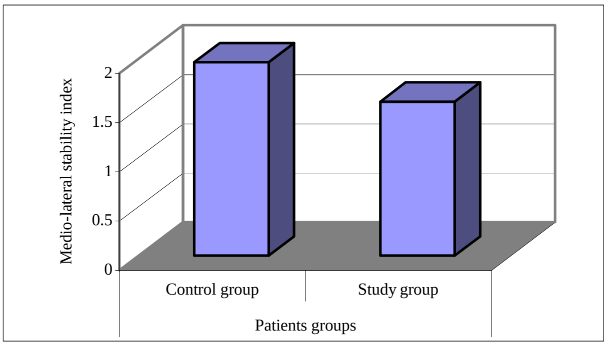

Fig. (3): Demonstrating the Post-treatment mean values of medio-lateral stability index for both groups.

DISCUSSION

Children with CP suffer from multiple problems as impaired balance, gait disturbances and frequent falls. Spastic diplegic children were found to demonstrate deficits in postural control system that may provide a partial explanation for balance problems that are common in these children.

Numerous articles have been published regarding the effect of electrical stimulation on strengthening skeletal muscle. Perhaps the most remarkable findings had been come from the investigations conducted that electrical muscle stimulation can be an effective means of increasing strength in subjects as more motor units, within a given muscle, could be recruited through electrical stimulation than by a voluntary contraction of that same muscle also high intensity currents can give contractions 10 to 30 percent higher than maximal voluntary contractions[24].

The aim of this study was to determine the effect of high voltage pulsed galvanic stimulation on standing balance in children with spastic diplegia who were unable to maintain balance. This agree with Kerr and McDonough,[20] who reported that electrical stimulation suggest to increases strength and motor function, and it is an attractive alternative for strengthening in children with poor selective motor control and with neuro-musculoskeletal dysfunction. Interest in the use of electrical stimulation in CP is growing.

The present study included spastic diplegic type of cerebral palsy, which constitutes a major classification among spastic types. This finding was reported by Binder and Eng,[4] who stated that spastic diplegia is the most prevalent type of CP, which accounts nearly about 42% of cerebral palsied children including premature children.

Conducting the study on children aged from six to eight years come in agreement Shumway-Cook and Woollacott,[34] who emphasized that, postural control is essentially adult like 6-10 years of age. The chosen age's bracket in this study was parallel to Sutherland et al.,[40] who reported that there is a complete maturation of gait and the pattern of gait at this age is very similar to the adult's pattern, so the developmental factor as a factor affecting the gait in these children can be excluded. This also comes in agreement with the finding of Koop and Green,[22] who reveled that independent standing and walking in spastic diplegia can be delayed up to six years of age because of inadequate hip flexion, extension and adductor spasticity of the legs.

The pre-treatment mean values of overall, anteroposterior and mediolateral stability index of the dynamic balance test showed a significant increase in their values which indicated that those children had a significant balance problems. This agrees with Testerman and Griend,[41] who emphasized that the larger the numerical value of the stability index, the greater the degree of difficulty or instability in balancing the platform, This was also confirmed by Horak et al.,[15] who concluded that spastic diplegic children have balance impairment affects their functional level particularly standing and walking activities which may produce abnormal motor behavior.

Kirker et al.,[21] reported that, these postural impairments affect the ability to respond to challenges to balance efficiently additionally the automatic postural response is often disrupted especially with CP which frequently contributes to impairments in standing balance, leading to difficulty in walking. This comes in agreement with Styer-Acevedo,[39] who revealed; the ability of the human to maintain normal posture and to balance relies on the activity of a large number of muscles which balance the spinal column and maintain the overall mechanical integrity of the trunk. Children with spasticity typically tend to have decreased active balance of trunk flexors and extensors in an upright position with difficulty sustaining muscle activation.

Statistical analysis of the post treatment results of the two groups revealed significant improvement in postural stability and functional ability, which is represented by keeping the body segments properly aligned in upright posture, and was expressed by a reduction of biodex dynamic balance test values.

Improvement fulfilled in the control group might be attributed to the effect of the therapeutic exercise program, which emphasized on a group of exercises for facilitation of normal erect posture. This comes in agreement with Kern et al.,[19] who established that traditional methods of treatment for children with cerebral palsy are focused on the attainment of sequential developmental milestones and facilitation of normal movement patterns. The significant improvement in the post-treatment results in the control group also comes in agreement with Sterba et al.,[38] who recommended strengthening of the trunk and core muscles, promotion of postural and equilibrium reactions, and focus on postural alignment in sitting, standing and walking considered as components of physical therapy treatment plans for pediatric therapists who rehabilitate children with neurological conditions.

The goals of the desired exercise program were to develop greater variety of movement patterns, particularly in the trunk through the neurodevelopmental approach. The exercise program was designed to provide postural adaptation to improve equilibrium in all positions as well as to provide opportunity for age appropriate skills and locomotion. The improvement seen in the control group may be attributed to the development of proper alignment of posture provided by the different exercises for facilitation of normal erect posture as stated by Horak and Macpherson,[14] These results were consistent with those reported by Rybski,[32] who indicated that every movement made or posture assumed in the lower extremity or trunk is interrelated and when considering posture or positioning of a patient, the relationship between the trunk and the hip is essential. This was supported by the opinion of Farmer and Mcneely,[10] who stated that the practice of muscle interaction during training would heighten sensory awareness of the balanced trunk and increased muscular control.

In addition exercises allows better motor function, more postural control, and it is effective tool in treatment of abnormal back geometry exercises which enhances the functional abilities of most children with spastic diplegia[19].

In respect to the study group who received electrical stimulation therapy, there was significant improvement in the mean values of stability indices which come in consistent with Parker et al.,[29] who reported that, the strength by ES is sufficient enough to cause prolonged contraction in the stimulated muscles due to prolonged repeated firing of motor neurons. Additionally, Park et al.,[28] reported that electrical stimulation might be an effective tool for improving muscle strength, range of motion, sensory awareness and assisting motor learning and coordination as well.

The number of electrical stimulation training sessions required to produce strength gains is quite variable. Some investigators have reported significant strength gains in as few as 10 sessions but other researchers found significant increases in strength in 12 to 25 training sessions. Because few studies have used the same electrical stimulation characteristics and other published studies have used HVPGS are differences in stimulus characteristics and training protocols, comparisons between the published studies are somewhat difficult[11].

Improvement in the post treatment mean values of study group may be attributed to the increase of the activity of antigravity muscles which counteract the force of gravity and leads to modulation of postural control and maintenance of good alignment. This results come in agreement with Harris et al.,[12] who demonstrated that HVPGS has a great efficiency to augment muscle strength. The theoretical basis for its use in this field is fundamentally based on that the electrical stimulation of the muscle via its motor nerve can cause nearly all motor units in the muscle to contract synchronously that can't be achieved in voluntary contraction, and this of course would allowed more stronger muscle contractions to occur.

The post-treatment results of the study group reinforced the effectiveness of high voltage pulsed galvanic stimulation on improving standing balance by adopting suitable program of ES. This agrees with the findings of Kots and Grago[24] they found that electrical stimulation to be of benefit results in a variety of neuromuscular and musculoskeletal problems.

The post-treatment results of the study group was in agreement with the study of Korkmaz et al.,[23] who suggested that effects of High Voltage Pulsed Galvanic Stimulation with other rehabilitation techniques may be more appropriate and effective in treatment the weakness of knee flexors and ankle dorsiflexors, in Multiple Sclerosis patients. Also, Hazlewood et al.,[13] reported that electrical stimulation of the gluteus maximus are highly recommended and would improve hip extensor strength, decrease excessive passive and dynamic internal hip rotation, and improve gross motor function in children with cerebral palsy.

This improvement was also confirmed by Bax and Brown[3]. Who reported that The strengthening with HVPGS will be achieved by producing the highest muscular contraction forces possible in order to produce most rapid strength improvements. Also the post-treatment results were explained by Eccles,[9] who emphasized that muscular strength is more important to get efficient movement and provide stability within the joints, as well as performing activities of daily living without fatigue.

Significant improvement in the mean values of stability indices were consistent with those reported by Jenkins,[16] who reported that gluteus maximus is not only a hip extensor but also plays an important role in pelvic and spinal stabilization. It allows maintenance of upright position needed for bipedal movement. Through evolution the gluteus maximus enlarged in humans as a means to stabilize the trunk while standing and counteract the high impact forces that tend to flex the trunk anteriorly during running.

This also supported by findings of Shumway-Cook and Woollacott,[34] who described that the development of antigravity movement is strongly associated with the development of higher levels of postural control, balance and movement.

Other investigators are in disagreement with this study, however, and have found that electrical stimulation in the form of HVPGS is not an effective method of increasing strength[30]. The work done by Sommerfelt et al.,[36] who found static exercise superior to nine weeks (27 sessions) of electrical stimulation in increasing strength. Similarly, Dali et al.,[6] concluded that two weeks (10 sessions) of electrical stimulation combined with static exercise is no greater benefit than static exercise alone in enhancing strength. There was a lack of improvement noted in both postural and balance control in those subjects with neuromuscular problems.

However, significant improvement was also noticed when comparing the post-treatment results of the two groups in the favor of the study group. These results might be attributed the increased strength of trunk muscles as it is the key element for control of normal postural stability in the erect position. This come in agreement with Smidt and Rogers,[35] who stated that the importance of muscle strength to produce tension and control trunk movement. They were regulated by number of factors, included motor unit recruitment, motor neuron firing patterns, muscle fiber composition, type of contraction, length of muscle, velocity of contraction.

Also the post-treatment results were explained by Kahanovitz et al.,[17] who found that HVPGS had a valuable treatment in the in maintaining, increasing strength and endurance of back muscles when a associated with exercise program.

Improvement observed in this study comes in agreement with Stackhouse et al.,[37] who concluded that ES combined with exercises is better than exercise alone or ES alone. Additionally, Karabay et al.,[18] reported that, ES on abdomen-back muscles along with conventional therapy to maintain trunk control is more effective than conventional therapy alone for children with CP.

In conclusion, the children with spastic diplegic cerebral palsy showed better response to given treatment. Therefore, this study showed that electrical stimulation over back and hip muscles extensors might be useful therapeutic tool and can be added with physical therapy as an additional modality to improve balance and postural reactions of diplegic children.

REFERENCES

1- Balaban, B., Yasar, E. and Dal ,U.: The effect of hinged ankle-foot orthosis on gait and energy expenditure in spastic diplegic cerebral palsy. Disability and Rehabilitation. 29(2): 139-144, 2007.
2- Balogun, J., Onilari, O. and AkeJu, O.: High voltage electrical stimulation in the Augmentation of muscle strength: Effect of pulse frequency Arch. Phys. Med. Rehabil.; 74: 910-915, 1993.
3- Bax, M. and Brown, J.: The spectrum of disorders known as cerebral palsy. In: Scrutton, D., and Mayston, M. (eds.), Management of the motor disorders of children with cerebral palsy, 2nd ed. London: Mac Keith press, 9-21, 2005.
4- Binder, H. and Eng, G.: Rehabilitation management of children with spastic diplegic cerebral palsy. Arch. Phys. Med. Rehabil. 70: 482-489, 2002.
5- Bohannon, R. and Smith, M.: Interrater reliability of a Modified Ashworth Scale of muscle spasticity. Phys Ther. 67: 206-207, 1987.
6- Dali, C., Hansen, F. and Pedersen, S.: Threshold electrical stimulation in ambulant children with CP: a randomized double-blind

placebo controlled clinical trial. Dev Med Child Neurol 44: 364-369, 2002.

7- Damiano, D. and Abel, M.: Functional outcomes of strength training in spastic cerebral palsy. Arch Phys Med Rehabilitation; 79: 119-25, 1998.

8- De Oliveira, C., De Medeiros, I. and Frota, N.: Balance control in hemiparetic stroke patients: main tools for evaluation. J Rehabil. Res. Dev.;45(8):1215-1226, 2008.

9- Eccles, A.: Static and dynamic optimization solution for gait are practically equivalent. J. Biomech. 14: 153-161, 1997.

10- Farmer, J. and Mcneely, P.: Surgery in the dorsal roots for children with cerebral palsy. Operative Techniques in Neurosurgery. 7(3): 153-156, 2004.

11- Gultekin, Z., Kin, A. and Surenkok, O.: Effect of electrical stimulation with high voltage pulsed galvanic current and Russian currents on lactic acid accumulation: a preliminary study. Fizyoter Rehabil.; 17(2): 89-94, 2006.

12- Harris, E., Guld, S. and Sam, N.: Maximum torque production in muscle after neuromuscular electrical stimulation , Br med J., 13: 111-115, 1999.

13- Hazlewood, M., Aitchison, A., Hillman, S. and Robb, J.: Electrical stimulation of gluteus maximus in children with cerebral palsy: effects on gait characteristics and muscle strength. Dev Med Child Neurol.; 45(6): 385-390, 2003.

14- Horak, B. and Macpherson, M.: Postural orientation and equilibrium. In Shephard, J. and Rowell, L. (Eds). Handbook of physiology. section 12. Exercise, 1996.

15- Horak, F., Diane, M. and Frank, J.: The balance evaluation systems test to differentiate balance deficits. Am Phys Ther Assoc; 89: 484-498, 2009.

16- Jenkins, D.: Functional anatomy of the limbs and back., 7th (ed) Philadelphia; London; Boston: WB Saunders, 1998.

17- Kahanovitz, N., Nordin, M. and Verderame, R.: Normal trunk muscle strength and endurance in woman and the effects of exercises and electrical stimulation, part 2: comparative analysis of electrical stimulation and exercises to increase trunk muscle strength and endurance. Spine 12: 112-118, 1987.

18- Karabay, I., Dogan, A. and Arslan, M.: Effects of functional electrical stimulation on trunk control in children with diplegic cerebral palsy. Disabil Rehabil.; 34(11): 965-970, 2012.

19- Kern, H., Horak, F. and Nashner, L.: Cerebral palsy. In: Campbell, S., editor. Decision making in pediatric neurologic physical therapy. Phil: Churchill Livingstone; 317-322, 2000.

20- Kerr, C. and McDonough, S.: Electrical stimulation in cerebral palsy: a review of effects on strength and motor function. Dev Med Child Neurol.; 46(3): 205-213, 2004.

21- Kirker, S., Simpson, D., Jenner, J. and Wing, A.: Stepping before standing: hip muscle function in stepping and standing balance after stroke. J Neurol Neurosurg Psychiatry; 68(4): 458-464, 2000.

22- Koop, O. and Green, E.: Early development of postural control. Physiotherapy. 76(12): 799-802, 1992.

23- Korkmaz, N., Kirdi, N., Temucin, C. and Yakut, Y.: Improvement of muscle strength and fatigue with high voltage pulsed galvanic stimulation in multiple sclerosis patients-a non-randomized controlled trial. J Pak Med Assoc.; 61(8): 736-743, 2011.

24- Kot, L. and Grago, L.: Effect of neuromuscular electrical stimulation on muscle strength, Arch.Phys.Med.Rehabil.,71: 701-705, 1990.

25- Liao, H. and Hwang, A.: Relations of balance function and gross motor ability for children with cerebral palsy. Percept Mot Skills; 96: 1173-1184, 2003.

26- Low, J., Reed, A. and Dyson, M.: Electrotherapy explained principles and practice 3rd ed, Butterworth Heinemann, 83-85, 101-200, 2000.

27- Olney, S. and Wright, M.: Cerebral palsy. In: Campbell, S., editor. Physical therapy for children. Philadelphia: W.B. Saunders; 496-500, 2000.

28- Park, E., Park, C., Lee, H. and Chro, Y.: The effect of electrical stimulation on the trunk control in spastic diplegic cerebral palsy. J Korean Med Sci., 16: 347-350, 2001.

29- Parker, R., Edward, S. and Saad, A.: Electrically elicited training contraction intensities and strength recovery in quqdriceps femoris muscle after anterior cruciate ligament reconstruction, J. rehabilitation. Med., 58: 223-227, 1995.

30- Porcari, J.P., McLean, K.P. and Foster, C.: Effects of electrical muscle stimulation on body composition, muscle strength, and physical appearance. J Strength Cond Res.; 16: 165-172, 2002.

31- Robert, J., Steven, E., Peter, L. and Beth, T.: Probability of walking, wheeled mobility, and assisted mobility in children and adolescents with cerebral palsy. Journal of development medicine & development. 52(1): 66-71, 2010.

32- Rybski, M.: The spine, pelvis, and posture. In Kinesiology for occupational therapy. SLACK Incorporated. 121-135, 2004.
33- Scherzer, A. and Tscharnuter, I.: Early diagnosis and therapy in cerebral palsy: A primer on infant developmental problems. Marcel Dekker, New York. 2nd ed: 89-101, 2001.
34- Shumway-Cook, A. and Woollacott, M.: Motor Control Theory and Practical Applications. Baltimore: Williams & Wilkins; 456-520, 1995.
35- Smidt, G. and Rogers, M.: Factors contributing to the regulation and clinical assessment of muscular strength. Physical Therapy. 62: 1283-1289, 1992.
36- Sommerfelt, K., Markestad, T. and Berg, K.: Therapeutic electrical stimulation in cerebral palsy: a randomized, controlled, cross-over trial. Dev Med Child Neurol.; 43(9): 609-613, 2001.
37- Stackhouse, S., Binder, S. and Stackhouse, C.: Neuromuscular electrical stimulation versus volitional isometric strength training in children with spastic diplegic cerebral palsy: a preliminary study. Neurorehabil Neural Repair.; 21(6): 475-485, 2007.
38- Sterba, J., Rogers, B., France, A. and Vokes, D.: Horseback riding in children with cerebral palsy: effect on gross motor function. Dev Med Child Neurol; 44(5): 301-308, 2002.
39- Styer-Acevedo, J.: Physical therapy for the child with cerebral palsy. In: Tecklin, J. Pediatric physical therapy. Lippincott Williams and Wilkins, Philadelphia. 3rd ed: 107-162, 1999.
40- Sutherland, D., Olshen, R., Biden, E. and Wyatt, M.: The development of mature walking. Philadelphia, Mac Keith Press, 88-92, 1988.
41- Testerman, C. and Griend, R.: Evaluation of ankle instability using the Biodex stability system. 20(5): 317-321, 1999.
42- Van der, M., Hazlewood, M. and Aitchison, A.: Electrical stimulation of gluteus maximus in children with cerebral palsy: effects on gait characteristics and muscle strength. Dev Med Child Neurol, 45(6): 385-390, 2003.
43- Wade, L., Canning, C. and Fowler, V.: Changing in posture sway and performance of functional task during rehabilitation after traumatic brain injury .Arch .Phys, Med. Rehabil.; 78(10): 1107-1111, 1997.
44- Woollacott, M. and Shumway-Cook, A.: Postural dysfunction during standing and walking in children with CP: what are the underlying problem and what new therapies might improve balance? Child Neural. ; 12: 2-3, 2005.
45- Woollacott, M. and Sveistrup, H.: longitudinal development of the automatic postural response in infants. J Mot Behav; 28(1): 58-70, 2007.
46- Yokochi, K.: Gait patterns in spastic diplegia and periventricular leukomalacia. Brain and Development. 23(1): 34-37, 2001.

الملخص العربي

دور التنبيه الكهربائي في تعديل الاتزان في الأطفال الذين يعانون من الشلل التقلصي المزدوج

خلفيه البحث والهدف : الحفاظ على الاتزان هو شرط ضروري لجميع أنشطة الأداء البشري ، معظم أطفال الشلل الدماغ ي يعانون من مشاكل في الاتزان ، التوافق العصبي العضلي وطريقة المشي في مرحلة الطفولة وما بعدها . يمثل الشلل التقلصي المزدوج النوع الأكثر شيوعا في مرضى الشلل المخي ، يظهر على هؤلاء الأطفال تأخير في اكتساب المهارات الحركية المختلفة مثل الوظائف الحركية الكبرى والدقيقة .فإنهم غالبا ما يفتقرون إلى الاستقرار الكافي وذلك بسبب اختلال التحكم في وضع الجسم والنغمة العضلية غير الطبيعية .الهدف من هذه الدراسة اختبار تأثير اثني عشر أسبوعا من التنبيه الكهربائي للعضلات الباسطة للظهر والعضلة الأليية الكبيرة على الوقوف المتوازن في أطفال الشلل التقلصي المزدوج . **عينة البحث :** ثلاثون طفلا من أطفال الشلل التقلصي المزدوج من الجنسين تتراوح أعمارهم بين السادسة و الثامنة سنوات ، تم تقسيمهم عشوائيا إلى مجموعتين متساويتين المجموعة الحاكمة (أ) ومجموعة الدراسة (ب) . **طريقة البحث :** تم تقييم قياسات الاتزان باستخدام جهاز البيودكس قبل و بعد ثلاثة شهور متواصلة من العلاج . المجموعة الحاكمة (أ) أخذت برنامج تمرينات مختارة بينما مجموعه الدراسة (ب) أخذت التنبيه الكهربائي في شكل الجهد العالي نابض التحفيز الجلفاني بالإضافة إلى برنامج التمرينات المختارة . **النتائج :** أظهرت نتائج البحث عدم وجود فروق ذات دلاله إحصائية بين جميع المتغيرات عند مقارنة نتائج التقييم قبل العلاج في المجموعتين بينما كان هناك تحسن ملحوظ في كل المتغيرات بين المجموعتين عند مقارنه النتائج قبل و بعد العلاج . كما وجد فروق ذات دلالة إحصائية عند مقارنه نتائج المجموعتين بعد العلاج لصالح مجموع ة الدراسة (ب) . **المناقشة والاستنتاج :** استخدام جهاز التنبيه الكهربائي له تأثير كبير في تحسين الاتزان فلذا يوصى باستخدامه بالتزامن مع برنامج التمرينات العلاجية المختلفة للأطفال ذوي الشلل التقلصى المزدوج .

الكلمات الدالة : الشلل التقلصي المزدوج ، الاتزان ، التنبيه الكهربائي .