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Effect of Functional Electrical Stimulation on Trunk Curvature in Spastic Quadriplegic Cerebral Palsied Children

Somaia Ali Hamed[1], Tamer Emam El-Negamy[2], Nevien Maher Waked[3]

[1]Department of physical therapy for pediatrics, Faculty of physical therapy, October 6 university, Egypt.
[2]Department of physical therapy for pediatrics, Faculty of physical therapy, October 6 university, Egypt.
[3]Lecturer of pediatrics, Faculty of Medicine October 6 University, Egypt.

Abstract: Background: The purpose of this study was to examine the effect of FES therapy on trunk curvature in children suffering from spastic quadriplegic cerebral palsy. **Subject:** Thirty children ranging in age from 3.5 to 7 years. Were divided randomly into two groups of an equal numbers, control group which received selected physical therapy program and study group which received the same treatment program while receiving FES program for three successive months. **Methods:** Cobb's and kyphotic angles for each child was evaluated before and after three months of treatment by using Radiographic evaluations. The data were collected and analyzed using Independent t-tests and pairwise comparison tests to compare the difference between the results. **Results**: this study revealed that there were significant differences of the measured variables between the control and study groups **Conclusion:** FES therapy program has got clear effect when added to the treatment program in spastic cerebral palsy.
Key Words: cerebral palsy, Cobb's angle, kyphotic angle.

Introduction:

Cerebral palsy refers to a mixture of posture and mobility dysfunctions due to a non progressive lesion that affects the developing central nervous system. Typically, the diagnosis can be drawn out before two years of age[1]. The analytical presentation of cerebral palsy (CP) obtained from one to seven per thousand children all over the world, theoretically, it's found more in geographic regions where prenatal maternal and prenatal infants' cares are poor[2].

Cerebral palsy can't be considered a particular diagnosis; it's more of a description that covered a number of neurological conditions resulting in abnormal development of movement and posture. CP is an umbrella term covering a group of non progressive but often fluctuating, motor impairment syndromes secondary to lesions or anomalies of the brain arising in the early stages of its development[3]. Impaired postural control is one of the main problems for children with CP; Children with cerebral palsy may show a delay in the acquisition of gross motor function such as postural control, so they developed lack of head and trunk stability[4].

The main objective of treatment for children with CP are to enable them to perform the activities of daily living as independently as possible to reduce their dependence on family members and to improve their quality of life thus maintaining a correct sitting position is the almost importance because it enables the upper extremities to efficiently perform everyday tasks.[5]

Cerebral palsy (CP) is the commonest cause of neuromuscular spinal deformity. The prevalence of spinal deformity in patients with CP is considered to be around 25%. It must be realized that the prevalence of spinal deformity depends on several factors such as the severity of the neurological deficit and the physiological division into which the patients' lies. Spinal deformity is more common in spastic CP[6].

Functional Electrical Stimulation (FES) is a technique that uses low energy electrical pulses to artificially generate body movements in individuals who have been paralyzed due to injury to the central nervous system. More specifically, FES can be used to generate muscle contraction in otherwise paralyzed limbs to produce functions such as grasping, walking, bladder voiding and standing. This technology was originally used to develop neuroprostheses that were implemented to permanently substitute impaired functions in individuals with spinal cord injury (SCI), head injury, stroke and other neurological disorders. FES is sometimes also referred to as Neuromuscular Electrical Stimulation (NMES)[7].

Few studies on the effects of FES in pediatric patient with CP have been published [8] however literature reveals numerous studies on FES application and its efficiency in adults[9]. FES was shown to be effective in prevention of upper extremity shoulder subluxation in hemiplegic patient [10] improvement of gait pattern [11] treatment of spasticity [12] prevent pressure ulcers[13] stimulation of phrenic nerve[14] urinary incontinence[15].

Patients, instrumentation and procedures

Thirty spastic quadriplegic cerebral palsied children of both sex participated in this study. They were selected from the outpatient clinic of Faculty of Physical Therapy October6 University Their ages ranged from 3.5 to 7 years, they had grade 1+ to 2 spasticity according to Modified Ashwarth Scale, children were subsequently excluded for any of the following reasons: they were medically unstable as determined by, history, or medical records, they had epilepsy, visual or auditory problems.

Children were randomly assigned into two groups of an equal number (A and B).Group A (control) received a designed exercise program for spastic quadriplegia with emphasis on facilitation of sitting and trunk control, while group B (study) received conventional therapy in addition to FES, Cobb's and kyphotic angle for each child was evaluated before and after three months of treatment by using radiographic evaluations

Program procedures:

- Both groups received the following program:

Patients of the control group received a selected physical therapy program for one hour per session, three times per week for three successive months directed towards improving the physical condition of the child in a form of:

All the patients underwent Neuro-developmental treatments (Bobath technique) aim to form normal motion patterns by normalizing the tonus of the muscles, inhibiting abnormal reflexes and facilitating automatic reactions in order to modify or inhibit spasticity and abnormal reflex patterns.

Back and abdominal exercises to prevent spinal deformities and improve trunk control. Facilitation of posture reaction including stimulation of equilibrium reaction from sitting on ball stimulation of protective reaction from sitting on ball by tilting the child in different directions forward, backward and side way exercises to maintain the optimum length of the muscle especially the tendoachilles, hamstrings, hip flexors and adductors in the lower limbs were done.

However, two-channel self adapting multimodal electro stimulator (SAMMS Mod Professional) and four-surface electrodes with the size of 5.5 * 6.5 cm were used in the treatment of the FES group included simultaneous electrical stimulation of the lumbar and abdominal muscles for 30 minutes per session 3 times per week for successive three months. FES was applied with the children in supported sitting position. Two of the four electrodes were placed on 1 cm over and under the umbilicus line of the abdominal muscles, whereas the other two of the four electrodes were placed over the paravertebral muscles on the midline of the lumbar region at 1cm intervals. The electrical stimulation was administrated as follows: intensity, 20 to 30 mA; sequence pulse width, 250 us; frequency, 25 Hz; sequence, on for 10s and then off 10s. The level of the stimulation was

increased until contraction was observed. The level of the stimulation was increased when the patients became more accommodated to it.

Radiographic evaluations:

To standardize the evaluation all the patients sat in the same positions (erect on a small stool with arms at the sides, knees flexed at a 90˚ angle and head facing frontward), sit as straight as possible. The angle of scoliosis was measured on the antero-posterior radiograph by means of the Cobb method. Lateral films were used to measure the kyphotic angle. A kyphotic angle pointing to a rounded back (normal range, 20˚ to 40˚) was measured with the Cobb method using the lateral graph[16].

Results:

- **Statistical Analysis**

All statistical measures were performed using the Statistical Package for Social science (SPSS) program version 18 for windows. Prior to final analysis, data were screened for normality assumption, and presence of extreme scores. This exploration was done as a pre-requisite for parametric calculation of the analysis of difference and analysis of relationship measures. To determine similarity between the groups at base line, subject age, height, and body weight were compared using independent t tests.

The current test involved two independent variables. The first one was the tested group which had two levels (group A & group B). The second one was the measuring periods which had two levels (pre and post). The two dependent variables were kyphotic and cobb's angles. Accordingly, 2×2 Mixed design MANOVA was used to compare the tested variables of interest at different tested groups and measuring periods. MANOVA was conducted with the initial alpha level set at 0.05.

- **Analysis**

1- Demographic data

Thirty patients participated in the study. They were randomly assigned equally into two groups; study group and control group. Independent t-tests were conducted to compare between both groups for the demographic data (age, weight, and height). The independent t-test revealed that there were no statistically significant differences (P>0.05) between subjects in both groups concerning age, weight, and height (Table 1).

Table (1): Descriptive statistics and independent t tests for the participants' demographic data for both groups.

	Study group (X±SD)	Control group (X ±SD)	t-value	p-value	Level of significant
Age (years)	5.42 ±0.83	5.38 ±0.74	0.115	0.909	N.S
Weight (kg)	20.53±3.96	20.5±3.96	0.018	0.985	N.S
Height (m)	1.006±0.11	1.008±0.08	-0.054	0.957	N.S

***Significant level is set at alpha level <0.05**

Kyphotic and Cobb's Angles

Statistical analysis revealed that there were significant within subject effect (F = 484.138, p= 0.000), and treatment*time effect (F= 83.531, p= 0.016), and between subject effect (F = 39.945, p= 0.645). Table (2) represents descriptive statistic (mean ± SD) of all variables in both groups. Multiple pairwise comparison tests revealed that there were significant decreases (p <0.05) in kyphotic and cobb's angles in the post treatment condition compared with the pre treatment one in both groups.

Regarding between subject effects multiple pairwise comparisons revealed that the mean values of the "pre" treatment between both groups showed no significant differences in kyphotic and cobb's angles (p >0.05). While, there were significant decreases (p < 0.05) in kyphotic and cobb's angles in group B compared with

group A. Table (2) represents multiple pairwise comparisons between pre and post treatment values and between group A and group B of all variables in both groups.

Table (2): Mean ±SD values of the all dependent variables pre and post test in both groups.

	Measuring periods	Kyphotic angle	Cobb's angle
Study group	Pre test	45.85±1.75	8.75±0.66
	Post test	29.14	4.37±0.75
Control group	Pre test	44.85±1.23	8.24±0.85
	Post test	38.046	6.41±0.80

Table (3): 2×2 mixed design MANOVA for all dependent variables at different measuring periods at both groups.

Multiple pairwise comparison tests (Post hoc tests) for all dependent variables within groups		
Pre Vs. post	**Kyphotic angle**	**Cobb's angle**
Study	**0.000***	**0.000***
Control	0.000*	0.000*
Multiple pairwise comparison tests (Post hoc tests) for all dependent variables between both groups at different measuring periods		
Study Vs. control groups	**Kyphotic angle**	**Cobb's angle**
Pre	0.082	0.079
Post	0.000*	0.000*

***Significant at alpha level <0.05**

Discussion:

The purpose of this study was to evaluate the effect of functional electrical stimulation program on trunk curvature in children suffering from spastic quadriplegic cerebral palsy. Thirty children ranging in age from 3.5 to 7 years were chosen from the outpatient clinic of the Faculty of Physical Therapy octber6 University. Both sexes were involved. Subjects were divided randomly into two groups of an equal numbers, control group which received selected physical therapy program and study group which received the same treatment program while receiving FES program for three successive months.

Neuromuscular electrical stimulation (NMES) has been shown to be useful in the rehabilitation of neurological patient[17] however, in neuropediatric physical therapy this kind of procedures has not yet been widely explored . Since therapist fear increasing spasticity through electrical stimulation. For this reason NMES is not common practice for CP patients. Although it has been used for research on CP subjects, usually with high weekly frequency of treatment, or up to twice a day by some authors[18]. These protocols are used mainly for research, and they do not reflect what can be done in large-scale therapy. although NMES is applied to specific muscles , increase in overall functioning after its use have been document , because increases in strength and range of movement (ROM) can lead the child to use the limb more effectively[19].

The positive results of studies that used electrical stimulation to improve the function of the lower extremities and the walking pattern in children with CP have been emphasized. In children with CP, maintaining a balanced sitting and standing position, which reduces dependency in performing the activities of daily living, is of crucial importance.

The post treatment results of this study revealed an improvement in the mean values of the measured variables of the control group which received a selected physical therapy program which confirm the effectiveness of the pediatrics physical therapy techniques in the treatment of cerebral palsy. While there is a

significant improvement in the study group rather than the control group. This may be due to the positive effects of electrical stimulation on the muscles strength, volume and contraction.

This come in agreement with [20]who stated that Electrical stimulation of nervous tissue may be used to trigger action potential in axons membrane to threshold depolarizing some portion of the axon membrane to threshold when ES is applied appropriately to the motor nerves that innervate skeletal muscle, it can induce muscle contraction. Repetitive ES of these motor nerves is efficacious therapy for patient with various neuromuscular disorders including stroke[21] and spinal cord injury[22, 23].

This effect may improve the efficiency of back and abdominal muscles motor units and so increasing the child control on his trunk musculature. Also the improvement May be due to increasing blood flow of the skeletal muscles which improve their function. [24]mentioned in his review that FES has an autonomic effect through inhibiting sympathetic tone which leads to increasing neural and muscular blood supply through domination of parasympathetic autonomic nervous system .

At the central level the improvement may be due to increased reorganization of motor area of the brain as [25] stated that ES increases the grade of reorganization in the motor area of the brain due to the well-known effect of neural plasticity, according to the theory of motor learning, the activity has to be repetitive, focused on the aim and the limit of performance[26].

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