Efficacy of Electrical Stimulation on Sitting Balance in Children with Spastic Athetoid Cerebral Palsy

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ABSTRACT

The purpose of this study was to determine the effectiveness of electrical stimulation over the trunk in improving sitting balance in children with spastic athetoid cerebral palsy who displayed poor trunk control. Twenty-six subjects, ranged in age from 5 to 12 years, were randomly assigned to two equal groups. Both groups received physical therapy for 6 weeks. The study group had additional electrical stimulation over the abdomen and posterior back muscles. Radiographic studies were carried out on the whole spine while the children were sitting before and after treatment. Kyphotic, Cobb's and lumbosacral angles were measured. Additionally, sitting score-Gross Motor Function Measure (GMFM) was also evaluated. There was no significant difference of these values at initial evaluation between the two groups. Following 6 weeks of intensive therapy, the kyphotic angle was significantly lower and the sitting score-GMFM was significantly higher in the study group when compared with those of the control group. The Cobb's angle flowing treatment was improved in the study group, but not statistically compared with that of the control group. This study suggests that electrical stimulation over the trunk become a beneficial therapeutic technique in improving sitting posture and trunk control in children with spastic athetoid cerebral palsy.
Key words: *Electrical stimulation; Cerebral palsy; Sitting balance.*

INTRODUCTION

Cerebral palsy is an umbrella term covering a group of non-progressive, but often changing, motor impairment syndromes secondary to lesions or anomalies of the brain arising in early stages of its development. Three main kinds of motor disorders are seen in CP children: spastic paresis, ataxic paresis and dyskinetic paresis. In addition, a mixed CP (about one-fourth of all people with CP), which includes combination of the previously mentioned types, might be present. Spastic athetoid CP is the most common type of mixed CP. Dyskinetic paresis can be divided into the hyperkinetic (athetoid) type, characterized by involuntary movements, most pronounced in the face and extremities, and the dystonic type, characterized by slow powerful contractions of agonist and antagonist of movement simultaneous, locally or with total body movement. The development of head and trunk balance is delayed in both types. Children with athetoid CP have trouble holding themselves in an upright, steady position for sitting or walking. About one-fourth of all people with CP have athetoid CP. The main classic presentation of dyskinetic CP include hypotonia and movement problems, some spasticity, oral-motor dysfunction, gait disorders, unstable trunk and possible deafness[11].

Interest in the area of cerebral palsy (CP) and electrical stimulation (ES) continues to grow because it has potential as a passive, non-invasive, home-based therapy, which is claimed to result in gains in strength and motor function[1,9,23]. If proved effective it might provide an alternative to resistive exercises techniques for children with poor selective muscle control, or indeed it might improve treatment compliance in those children who find exercise programs difficult.

Essentially, two variations of ES are used in muscle strengthening in children with CP: neuromuscular electrical stimulation (NMES) and threshold electrical stimulation (TES). Neuromuscular ES is the application of an electrical current of sufficient intensity to elicit muscle contraction. To elicit a contraction, two electrodes are placed on the skin overlaying the target musculature. Contraction occurs through the stimulation of the intramuscular branches of the nerve supplying the muscle. Two strengthening mechanisms are proposed: first, the overload principle, resulting in greater muscle strength by increasing the cross-sectional area of the muscle, and second, selective recruitment of type II fibers (fast twitch, large diameter fibers), causing improved synaptic efficiency of the muscle. Stimulation can be applied regardless the nature of the activity that the patient is participating in. However, when applies in a task-specific manner in which a muscle is stimulated when it should be contracting during a functional activity, the stimulation is referred to as functional electrical stimulation (FES)[18].

Alternatively, TES has been described as a low-level, subcontraction electrical stimulus applied at home during sleep[15]. The author proposed that increased blood flow during a time of heightened trophic hormone secretion could result in increased muscle bulk.

Dubowitz et al. (1988)[7] applied ES to the tibialis anterior of two children with hemiplegia while they were active. They reported an increase in the maximum voluntary contraction during ankle dorsiflexion and a subjective improvement in motor performance and gait.

Wright and Granat (2000)[23] applied ES to the wrist extensor muscles of 8 children with CP for 30 minutes daily for 6 weeks. Their study design included a baseline, treatment and follow-up period. A significant improvement in hand function and active wrist extension was found after the treatment period and these improvements were maintained until the end of the 6-week follow-up period.

Sitting is an important step for child to achieve the upright posture against gravity and an essential activity to provide the postural background tone required for the functional movement of the upper extremity. However, the children with CP often show the difficulty to achieve well-balanced sitting posture and display the poor sitting posture such as flexed trunk with kyphotic curvature of the spine and asymmetry of the trunk[17]. Coordinated activation of extensors and flexors of trunk as well as hip is required for well-balanced sitting posture[21]. In the spastic CP, weakness has been recognized as clinical characteristics[6]. From the perspective of this point, it is assumed that the sitting balance or posture in these children might be improved with the strengthening of trunk muscles.

Based on these previously mentioned reports, it can assumed that if ES over abdomen and posterior back muscles is given to a child with spastic athetoid CP who had poor trunk control, it may result in improvement of the trunk control. Therefore, this study was designed to investigate the effectiveness of ES over abdomen and posterior back muscles in improving trunk control in children with spastic athetoid CP who had poor sitting posture.

SUBJECTS, MATERIALS AND PROCEDURES

Subjects

Twenty-six children with spastic athetoid CP were enrolled as subjects. They displayed abnormal brain MRI as well as abnormal neurological signs such as hypertonia in the upper and lower extremities, involuntary movements of the distal extremities, ankle clonus and delayed motor development. The subjects were randomly divided into two equal groups (control and study). The age was ranged fro 5 to 12 years. There was no significant difference of mean age between the two groups. All children were selected from the Outpatient Pediatric Clinic in King Khaled Hospital, King Saud University, Saudi Arabia. The children with fixed skeletal or hip deformities or seizure were excluded. This study was given ethical approval from Research Center in King Khaled Hospital. Parents of the children were informed of all aspects of the study and were gave their consents. The general characteristics of the participants are shown in Table (1).

Table (1): General characteristics of the subjects.

Group	Number of Children	Age (Year)		Sex	
		Mean	SD	Boy	Girl
Control	13	7.95	±2.49	8	5
Study	13	8.03	±2.29	9	4

SD: Standard deviation.

Materials

Microstim electrical stimulator was used for the electrical stimulation (Medizinsche Electronik, Handelsgeselleschaft Medel GmbH, Germany). Plain anterior-posterior and lateral radiographs were used to measure the Cobb's angle, kyphotic as well as lumbosacral angles. Gross Motor Function Measure (GMFM) was used to evaluate sitting posture[19].

Procedures

All children in both groups had basically the same selected physical therapy program that was based on Neuro-Developmental Technique (NDT) for one hour/day, 5 days/week for 6 continuous weeks. The study group had additional electrical therapeutic session. Electrical stimulation was delivered over the abdomen and posterior back muscles for 30 minutes/day all over the time of the study. The characteristics of the ES were 25-30 mA intensity, 250µsec pulse width, 35 Hz frequency, 10 sec on/12 sec off interval. The intensity of ES was adjusted to the tolerance of the child, which was kept at the intensity of muscle contraction felt. Electrical stimulation on abdomen and posterior back muscles was delivered simultaneously. Sitting score of GMFM was assessed in all children before and after 6 weeks of treatment. Plain anterior-posterior and lateral radiographs of whole spine were evaluated before treatment as baseline and were reevaluated after 6 weeks of treatment. Radiographs were taken while the child was sitting on a chair without arm rest with 90 degrees of knees flexion and neutral ankle position. The upper extremities of the child were positioned at their sides. To make same emotional condition of child during a radiologic study, it was performed in calm down state. The Cobb's angle from the anterior-posterior film as well as kyphotic and lumbosacral angles from lateral film were measured. In this study, the Cobb's angle might represent the magnitude of functional trunk asymmetry of the spine and the kyphotic angle might represent the magnitude of round back. Kyphotic angle was measured as follows; first, both ends of vertebrae of kyphotic curve were identified on the lateral whole spine film and then a line along the upper end plate of the upper end vertebrae and the other line along the lower end plate of lower end vertebrae were drawn. At last, the angle formed by these two lines was measured. Cobb's angle was measured through the same procedure from the anterior-posterior film[3]. Lumbosacral angle was defined as an angle formed by the two lines of upper margin of first sacral vertebrae and horizontal line.

Data Analysis

In comparing the improvement after the intervention in each group, paired t-test was used and for the difference between the two groups, independent t-test was used. A value of $p<0.05$ was considered as significant.

RESULTS

Data of baseline before the treatment are shown in Table (2). The Cobb's, Kyphotic and lumbosacral angles and gross motor function measure (GMFM)-sitting scores at initial evaluation were not significantly different between the two groups.

Table (2): Baseline evaluation in two groups.

Measurements	Study Group	Control Group
Cobb's angle (°)	11.83±5.97	8.34±3.89
Kyphotic angle (°)	45.19±16.43	42.84±13.79
Lumbosacral angle (°)	1.92±11.67	5.51±11.11
GMFM-sitting (%)	29.86±18.51	31.69±38.26

In control group, Kyphotic angle was significantly decreased and GMFM-sitting score was significantly increased after treatment, but Cobb's angle was not significantly affected (Table 3).

Table (3): Changes of measurements before and after treatment in control group.

Measurements	Before	After
Cobb's angle (°)	8.34±3.89	6.01±3.47
Kyphotic angle (°)	42.84±13.79	34.18±9.55*
Lumbosacral angle (°)	5.51±11.11	4.84±5.96
GMFM-sitting (%)	31.69±38.26	42.49±35.22*

* $p<0.05$

After 6 weeks of treatment in the study group, the Cobb's angle and Kyphotic angle were significantly decreased while the GMFM-sitting score was significantly increased when compared with those at initial evaluation (Table 4).

Table (4): Changes of measurements before and after treatment in study group.

Measurements	Before	After
Cobb's angle (°)	11.83±5.97	7.83±5.39*
Kyphotic angle (°)	45.19±16.43	27.03±8.03*
Lumbosacral angle (°)	1.92±11.67	2.28±8.63
GMFM-sitting (%)	29.86±18.51	48.81±21.01*

* $p<0.05$

Comparing the changes of measurements after treatment between both groups, there was a significant decrease in the kyphotic angle as well as a significant increase in the GMFM-sitting score in the study group (Table 5 and Figure 1).

Table (5): Comparison of changes of measurements after 6 weeks of treatment.

Measurements	Study Group	Control Group
Cobb's angle (º)	7.83±5.39	6.01±3.47
Kyphotic angle (º)	27.03±8.03*	34.18±9.55
Lumbosacral angle (º)	2.28±8.63	4.84±5.96
GMFM-sitting (%)	48.81±21.01*	42.49±35.22

*p<0.05

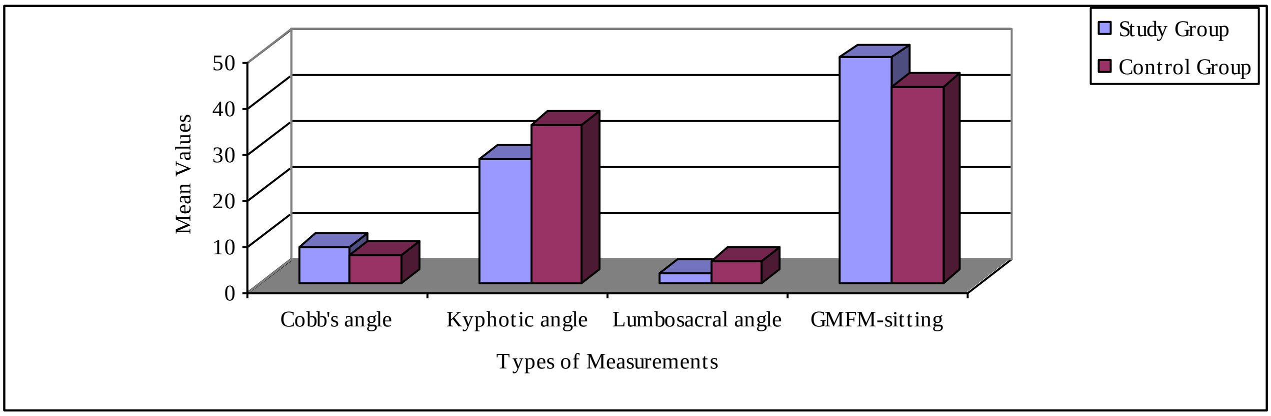

Fig. (1): Measurements in both groups after 6 weeks of treatment.

DISCUSSION

To verify the effect of ES on the trunk control, sitting posture and sitting balance were evaluated. The spastic athetoid CP children with poor trunk control show rounded back and trunk asymmetry while they are sitting. From the perspective of this point, I postulated that the kyphotic and Cobb's angles in sitting posture be able to represent the functional kyphosis and trunk asymmetry, respectively. Therefore, the radiographic study was chosen for quantitative evaluation of sitting posture. To standardize the evaluation method of sitting posture, the child was seated on a chair, the height of which was adjusted to maintain the knees in 90 degree flexed position and the ankles in neutral position. However, the change of pelvic position might influence the superincumbent spinal curve[2]. To control this effect, the lumbosacral angle was measured while the children were sitting. The sitting score part of the GMFM was used for assessing clinical changes of sitting balance.

Bly (1994)[2] reported that coordinated activation of extensors and flexors of trunk should be achieved for child to have a well-balanced sitting position. The child who cannot extend the trunk against gravity demonstrates a rounded back in sitting. If the child does not have sufficient abdominal muscle strength, the child tends to lean forward to eliminate the need for the action by that muscle group.

Electrical stimulation therapy for limb musculatures has been studies in patients with upper motor neuron lesions as well as in patients with CP[4,5,6,7,8,9,10,12,14,16,20]. The results of these studies indicated that ES might be an effective tool for improving muscle strength, range of motion, sensory awareness and assisting motor learning and coordination as well. Park et al. (2001)[17] described the effect of ES applied to the trunk muscles in very young children with spastic diplegic CP (aged 8 to 16 months) on improving trunk control. They revealed a significant improvement in sitting balance. On the other hand, Linden et al. (2003)[13] investigated the effect of ES of gluteus maximum on improving hip extensor strength, decreasing excessive passive and dynamic internal hip rotation and on improving gross motor function in children with spastic CP (aged 5 to 14 years). They found no statistically or clinically significant improvement in the stimulation group when compared with the control group after 8 weeks of treatment. However, the effect of ES over the trunk for enhancing trunk control has not clearly evaluated in older children with upper motor neuron lesion yet.

The effect of ES on improving the strength of trunk muscles was first documented by Kahanovitz et al. (1987)[10]. The study indicated that low frequency ES significantly increased isokinetic strength and endurance. Steinbok et al. (1997)[22] tried therapeutic ES over the muscles of the abdominal as well as proximal lower limb in patients with CP who had undergone selective posterior rhizotomy procedure. They used very low intensity ES, which did not cause muscle contraction. The study revealed the greater improvement in overall GMFM score in ES group without significant difference of muscle strength in limb muscles or of the sitting postural control between the ES and control groups. The present study was focused on revealing the effect of ES on enhancing trunk control. There was an increase in the sitting score of GMFG as well as a decrease in the kyphotic angle after the treatment in both groups. The improvement in the study group was significantly greater than in the control group. The Cobb's angle showed a significant change after treatment in the study group only. It might be considered as a consequence of reduced trunk asymmetry due to improved trunk control in the study group. On the other hand, no significant change in the lumbosacral angles before and after treatment was observed. This indicates that the changes in the kyphotic angle might be resulted from the improvement of trunk control rather than from the secondary changes induced by pelvic positional changes.

After 6 weeks of treatment, the children showed significant improvement in sitting control and posture despite relatively short duration of treatment. This improvement in both groups might be due to the intensive physical therapy for 6 weeks. Therefore, this study showed that the ES over the trunk might be a useful therapeutic tool for children with spastic athetoid CP who have poor trunk control, if combined with traditional physical therapy program.

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الملخص العربي

تأثير التنبيه الكهربائي على إتزان الجلوس لدى الأطفال المصابين بالشلل المخى

تهدف هذه الدراسة إلى تقييم تأثير العلاج بالتنبيه الكهربائي على عضلات البطن و الظهر في تحسن إتزان وضع الجلوس لدى الأطفال المصابين بالشلل المخى التشنجي المصاحب بحركات لاإرادية. تم إجراء هذا البحث على ستة و عشرون طفلا من المصابين بالشلل المخى التشنجي ممن تتراوح أعمارهم من 5 إلى 12 سنة. تم تقسيم المرضى عشوائيا إلى مجموعتين متساويتين في العدد. تلقت المجموعة الأولى برنامجا مكثفا من التمرينات العلاجية. و كذلك تلقت المجموعة الثانية نفس برنامج التمرينات العلاجية بالإضافة إلى جلسات العلاج بالتنبيه الكهربائي على عضلات البطن و الظهر . إستمر العلاج لمدة 6 أسابيع للمجموعتين. أستخدمت الأشعة السينية لكل العمود الفقري وذلك لقياس زاوية إنحناء الظهر للأمام و زاوية كوب و زاوية أسفل الظهر. كما تم تقييم وضع الجلوس وذلك باستخدام مقياس الوظائف الحركية (GMFM) . أوضحت الدراسة عدم وجود فروق ذات دلالة إحصائية لهذه القياسات بين المجموعتين وذلك قبل بدأ العلاج. بعد 6 أسابيع من العلاج، أظهرت النتائج تحسن معنوي في كل من زاوية إنحناء الظهر للأمام و وضع الجلوس في أطفال المجموعة الثانية عند مقارنتهم بأطفال المجموعة الأولى. يتضح من هذه النتائج أن التنبيه الكهربائي على عضلات البطن و الظهر يؤدى إلى تحسن وضع الجلوس لدى الأطفال المصابين بالشلل المخى التشنجي المصاحب بحركات لاإرادية.

الكلمات الدالة: الشلل المخى- العلاج الكهربائي- برنامج العلاج الطبيعي .