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The Effect of Electrical Stimulation on the Trunk Control in Young Children with Spastic Diplegic Cerebral Palsy

This study was designed to determine the effectiveness of electrical stimulation over the trunk in improving sitting balance in young children with spastic diplegic cerebral palsy who displayed poor trunk control. The subjects ranged in age from 8 to 16 months and were randomly assigned to two groups. Both group had physical therapy for 6 weeks. Electrical stimulation (ES) group had additional electrical stimulation over the abdomen and posterior back muscles. Radiographic studies were carried out on the whole spine while they were sitting before and after treatment. Kyphotic angle, Cobb's angle and lumbo-sacral angle were measured. Additionally, sitting score-Gross Motor Function Measure (GMFM) was also evaluated. There was no difference of these values at initial evaluation between the two groups. Following 6 weeks of intensive therapy, the changes of kyphotic angle and sitting score-GMFM were significantly higher in ES group statistically when compared with those of the control group. The Cobb's angle following treatment was improved in ES group, but not statistically compared with that of control group. This study suggests that electrical stimulation over the trunk become a beneficial therapeutic technique in improving the sitting posture and trunk control in young children with spastic diplegic cerebral palsy.

Key Words : *Electrical Stimulation; Trunk; Cerebral Palsy*

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INTRODUCTION

Sitting is an important step for child to achieve the upright posture against gravity and also an essential activity to provide the postural background tone required for the functional movement of upper extremity. However, the children with cerebral palsy 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 trunk.

Coordinated activation of extensors and flexors of trunk as well as hip is required for well-balanced sitting posture (1). In the spastic cerebral palsy, weakness has been recognized as clinical characteristics (2). 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. Electrical stimulation of muscles has been used for many years to increase muscle strength and to decrease the spasticity (3-8). Based on these reports, it can be assumed that if electrical stimulation over abdomen and posterior back muscles is given to a child with cerebral palsy who had poor trunk control, it may result in improvement of trunk control. Therefore, this study was designed to determine the effectiveness of electrical stimulation over abdomen and posterior back muscles in children with cerebral palsy who had poor sitting posture in improving the trunk control.

MATERIALS AND METHODS

Thirty-two children were enrolled as subjects. The clinical diagnosis of these children was spastic diplegic cerebral palsy. They displayed abnormal brain MRI or SPECT findings, as well as abnormal neurologic signs such as hypertonia in both lower limbs, ankle clonus, hyperactive deep tendon reflexes, and delayed motor development.

In thirty-two children, twenty-six were able to follow full work-ups. Characteristics of 26 children are shown in Table 1. The mean age of the children in the electrical stimulation (ES) group was 13.6 months and that of control group was 12.5 months. There was no significant difference of mean age between the two groups.

All of them had been admitted to our hospital for

Table 1. General characteristics of subjects

	ES group	Control group
Number of subjects	14	12
Age (mean±SD, months)	13.6±4.4	12.5±3.7
Male : Female	9 : 5	8 : 4

ES, electrical stimulation

intensive in-patient therapy. The children with fixed skeletal or hip deformities or seizure were excluded in this study. This study was given ethical approval from the Ethics Subcommittee for research involving human subjects. Parents or guardians of the children were informed of all aspects of the study and gave their consents.

All children were randomly assigned into two groups; ES or control group. All children in both groups had basically the same physical therapy that was based on Neuro-Developmental Technique (NDT) through the 6 weeks of hospital stay. While the ES group had additional electrical therapeutic session. The electrical stimulator that we used was Microstim (Medizinische Electronik, Handelsgesellschaft Medel GmbH, Germany). Electrical stimulation was delivered over the abdomen and posterior back muscles for 30 min per day and 6 days a week (Fig. 1). The characteristics of electrical stimulation was 25-30 mA intensity, 250 μsec pulse width, 35 Hz frequency, 10 sec on / 12 sec off interval. The intensity of electrical stimulation 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 Gross Motor Functional Measure (9) was assessed by one physical therapist in all children before and after 6 weeks of treatment. The physical therapist was not informed about the patients. Plain anterior-posterior and lateral radiographs of whole spine were evaluated before the treatment as baseline, and were reevaluated after the 6 weeks of treatment. Radiographs were taken while the child was sitting on a chair without arm rest with 90 degrees of knee 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 positioning the child and angular measurement of spine from radiography film were performed by one of the authors. The Cobb's angle from the anterior-posterior film and 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 usual method;

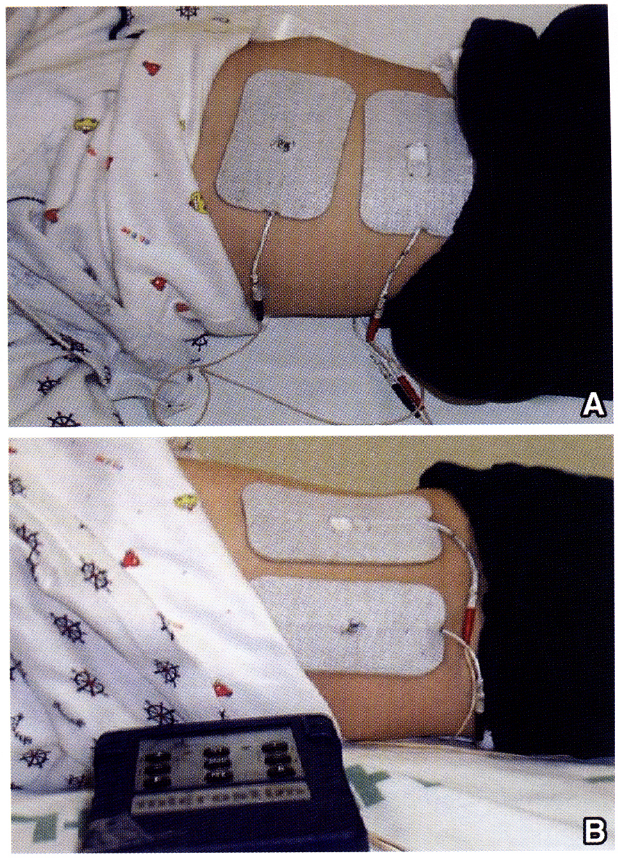

Fig. 1. Placement of electrodes: abdominal muscle (A), back muscles (B).

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 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 (10). Lumbosacral angle in this study was defined as an angle formed by the two lines of upper margin of first sacral vertebrae and horizontal line.

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

After 6 weeks' treatment, the Cobb's angle and

Table 2. Baseline evaluation in two groups

	ES group	Control group
Cobb's angle (°)	10.82±5.96	7.33±3.88
Kyphotic angle (°)	44.18±16.42	41.83±13.78
Lumbosacral angle (°)	1.91±11.66	5.50±11.10
GMFM-sitting (%)	29.85±18.50	31.68±38.25

ES, electrical stimulation

Table 3. Changes of measurements before and after treatment in electrical stimulation group

	Before	After
Cobb's angle (°)	10.82±5.96	6.82±5.38*
Kyphotic angle (°)	44.18±16.42	26.02±8.02*
Lumbosacral angle (°)	1.91±11.66	2.27±8.62
GMFM-sitting (%)	29.85±18.50	48.80±21.00*

*$p<0.05$

Table 4. Changes of measurements before and after treatment in control group

	Before	After
Cobb's angle (°)	7.33±3.88	5.00±3.46
Kyphotic angle (°)	41.83±13.78	33.17±9.54*
Lumbosacral angle (°)	5.50±11.10	4.83±5.95
GMFM-sitting (%)	31.68±38.25	42.48±35.21*

*$p<0.05$

Table 5. Comparison of changes of measurements after 6 weeks' treatment in each group

	ES group	Control group
Cobb's angle (°)	4.00±5.42	2.33±3.72
Kyphotic angle (°)	18.09±9.86*	8.67±6.02
Lumbosacral angle (°)	−1.09±5.01	0.67±6.50
GMFM-sitting (%)	18.95±9.05*	9.00±6.29

ES, electrical stimulation; *$p<0.05$

kyphotic angle were significantly decreased while the GMFM-sitting score was significantly increased when compared with those at initial evaluation (Table 3). In control group, kyphotic angle and GMFM-sitting score were significantly changed after treatment, but Cobb's angle was not (Table 4). Comparing the changes of measurements before and after treatment in each group, those of kyphotic angle and GMFM-sitting score in ES group were significantly greater than in control group (Table 5).

DISCUSSION

To verify the effect of electrical stimulation on the trunk control, sitting posture and sitting balance were evaluated. Our first concern was how to evaluate those quantitatively in very young children. The cerebral palsied children with poor trunk control show rounded back and trunk asymmetry while they are sitting. From the perspective of this point, we 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 the lower extremities of child 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 (11). To control this effect, the lumbosacral angle was also measured while they were sitting. Meanwhile, sitting score part of GMFM was used for assessing clinical changes of sitting balance.

Coordinated activation of extensors and flexors of trunk should be achieved for infant to have a well-balanced sitting position. The infant who cannot extend the trunk against gravity demonstrates a rounded back in sitting. If the infant does not have sufficient abdominal muscle strength, the infant tends to lean forward to eliminate the need for action by that muscle group (11).

The electrical stimulation therapy in the muscles of limb has been tried in patients with upper motor neuron lesion as well as in patients with cerebral palsy (2-4, 6, 7, 12-18). The results of the studies indicated 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. However, the effect of electrical stimulation over the trunk for enhancing trunk control has not been clearly evaluated in patients with upper motor neuron lesion yet.

The effect of electrical stimulation on improving the strength of trunk muscles was first documented by Kahanovitz et al. (18). That study indicated that low frequency electrical stimulation significantly increased isokinetic strength and endurance. Steinbok et al. tried therapeutic electrical stimulation over the muscles of abdomen as well as proximal lower limb in patients with cerebral palsy who had undergone selective posterior rhizotomy procedure (8). They used very low intensity electrical stimulation, 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. Our study was focused on revealing the effect of electrical stimulation on enhancing trunk control. Sitting score of GMFM and kyphotic angle after the treatment were increased in both groups, but the improvement in ES group was significantly greater than that in control group. The Cobb's angle showed a significant change after treatment in ES group only. It might be considered as a consequence of reduced trunk asymmetry due to improved trunk control in ES group. On the other hand, no significant change in lumbosacral angles before and after treatment was observed. This indicates that the changes in kyphotic angle might be resulted from the improvement of trunk control rather than from the secondary changes induced by pelvic positional changes.

Following the treatment, the children showed significant improvement in sitting control and posture despite relatively short duration of treatment. The improvement following 6 weeks' treatment in both groups might be due to the intensive physical therapy for 6 weeks of hospitalization, subjects' characteristics such as age, and the topographic classification of cerebral palsy. The subjects enrolled in this study were younger than two years old. Carmick reported that a 1.6 year-old young boy showed immediate and more rapid improvement with greater carryover effect to electrical stimulation, than did the older children (14, 15). They explained that the abnormal movement pattern and biomechanical changes of the muscles had not been established in these young children, so the changes after therapeutic intervention could be obtained more readily than in older children (14). In addition, the children were all spastic diplegic patients. Spastic diplegic patients basically have better trunk control and more potential of functional reorganization than spastic quadriplegic patients. It suggests that the children with spastic diplegic cerebral palsy show better response to given treatment than the children with spastic quadriplegic cerebral palsy. Therefore, this study showed that the electrical stimulation over the trunk might be a useful therapeutic tool for young and spastic diplegic children to achieve better trunk control, if combined with physical therapy.

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