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Efficacy of Trzanscranial Magnetic Stimulation on Balance in Children with Spastic Diplegia

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ABSTRACT

The propose of this study was to investigate the effect of transcranial magnetic stimulation on balance in children with spastic diplegic cerebral palsy. Fourty children of spastic diplegic cerebral palsy, ranged in age from 6 to 9 years, participated in this study. They were selected from both sex and were classified randomly into 2 groups of equal number twenty patients each, control group (A) and study group (B). Balance parameters were assessed using the Biodex stability system in both groups before and after three successive months of the application of the treatment program. The control group (A) received a selective physical therapy balance training program for 1 h. The study group (B) received the same program received by the control group in addition to application of Transcranial Magnetic Stimulation for 15 min at 15 Hz frequency. Before starting treatment program no significant difference was recorded between the mean values of the parameters used for evaluation of the two groups. The result also revealed statistically significant improvement in the measuring variables of both the control and study groups when comparing their pre and post treatment mean values. After treatment program significant difference was recorded between the two groups in favor of the study group, which support adding of transcranial magnetic stimulation for 15 min at 15 Hz frequency to the balance training program in rehabilitation of children with spastic diplegic cerebral palsy.

Key words: Diplegic cerebral palsy, balance, postural control and transcranial magnetic 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. The neurological disturbance associated with CP is non-progressive, secondary musculoskeletal impairments, pain and physical fatigue are thought to contribute to changes in motor function in adolescents and adults with CP that may include a decline in walking (Palisano *et al.*, 2010).

Children with spastic diplegia have some motor impairment of their upper extremities milder than lower ones. The primarily functional problems include difficulty with mobility and posture. Other problems include postural deviations including inability to sit without support, inability to stand and difficulty in movement transition (Sveistrup and Woollacott, 1996).

Balance deficits are one of the most common problems for spastic diplegia treated by physical therapists. Therapists need to identify who has a balance problem and then decide the best approach to rehabilitation (Horak *et al*., 2009).

Muscle imbalance, spasticity and deformities at the hips, knees and ankles contribute to the specific posture and gait patterns typical for diplegic CP as the following, Scissoring, Jumping gait, Crouch gait, Stiff knee, Genu recurvatum and Torsional deformities (Berker and Yalcin, 2008).

Transcranial Magnetic Stimulation (TMS) is a 2-decade-old method for focal noninvasive brain stimulation that is based on the principles of electromagnetic induction, where small intracranial electrical currents are generated in the cerebral cortex by a powerful fluctuating extracranial magnetic field (Kobayashi and Pascual-Leone, 2003).

Transcranial Magnetic Stimulation (TMS) shows promise as a novel nonpharmacologic diagnostic and therapeutic technique with applications in neurology, psychiatry and rehabilitation medicine (Pascual-Leone and Walsh, 2002).

Transcranial magnetic stimulation uses the principle of inductance to get electrical energy across the scalp and skull without pain of direct percutaneous electrical stimulation. It involves placing a small coil of wire on the scalp and passing a powerful and rapidly changing current through it. This produces a magnetic field which passes unimpeded and relatively painlessly through the tissues of the head. The peak strength of the magnetic field is related to the magnitude of the current and the number of turns of wire in the coil (Krings *et al*., 1997).

Transcranial magnetic stimulation, as a method of neuromodulation, was used on a large number of neurological diseases including stroke, Parkinson's disease, epilepsy, pain syndrome, cerebral palsy, etc. and showed success of this technique in spasticity control (Mori *et al*., 2009). The purpose of this study was to investigate the effect of Transcranial Magnetic Stimulation on balance in children with spastic diplegia.

MATERIALS AND METHODS

The subjects included in this study were fourty children with spastic diplegic cerebral palsy they were selected from the out-patient clinic, Faculty of Physical Therapy, Cairo University.

The criteria of the selection were:
Inclusive criteria:

- Their age was ranging from six to nine years
- Children participated in this study were from both sexes
- Their degree of spasticity ranged from mild to moderate according to Modified Ashworth Scale
- All children were able to walk supported or unsupported by the therapist
- All children had no fixed contractures or deformities at the lower limb
- All children were assessed at the Biodex balance system at stability level 8 and stability level 5

Exclusive criteria:

- Children with visual or auditory problems
- Children with history of epilepsy
- Children with structural joints deformities of the lower limbs

- Children with history of surgical interference in lower limbs less than one year
- Children with convulsions and fixed contractures

Design: The patient's sample was subdivided into two groups of equal number twenty patients each using closed envelops procedures.

The control group (A) received a selected physical therapy balance training program for 1 h and the study group (B) received the same treatment program of the control group in addition to application of transcranial magnetic stimulation for 15 min at 15 Hz frequency:

- All patients in both groups received 3 sessions/weak for 3 successive months

Instrumentation (materials)
For selection of patient criteria:

- Modified ashworth scale: was used to assess the degree of spasticity of all the children. The Ashworth Scale is a 5-points rating scale for measuring muscle tone with ratings from 0 ("no increase in tone") to 4 ("limb rigid in flexion or extension") (Bohannon and Smith, 1987)

Instrumentation
(A) For evaluation:

- Berg's Balance Scale (Berg's BS): Is a functional balance scale, is composed of 14 common balance items in every day life (Berg *et al.*, 1995)
- Biodex Balance System (BBS): Biodex balance system was to evaluate proprioceptive neuromuscular mechanisms that appear to affect both dynamic and static postural stability. These mechanisms are responsible for the initiation of muscle response that maintains body stability and posture stability (Hinman, 2000)
- All children were assessed before and after the treatment program by Berg's balance scale (Berg's BS) and Biodex balance system (BBS) using the Dynamic balance test (that include over all stability index, anteroposterior stability index and mediolateral stability index) which was performed on two levels of stability, level eight (the most stable) and level five (less stable)

(B) For treatment:

- Wedge, roll, mates
- Balance board
- Gravity force system
- Transcranial magnetic stimulation

Magnetic field for magneto therapy, its model is Automatic PMT Quattro and solenoids. The appliance must be connected to electrical mains supply pro. Serial number is 00001543. It consists of an appliance, motorized bed with 220 V±10% at a frequency of 50 Hz with earth connection. The intensity and spatial layout of the generated MF depend on the type of the used solenoid whether being for trunk, limb or transcranial Fig. 1-3. The output wave form is a sinusoidal wave, typical of the magneto therapy. Frequency of the output impulse ranged from 0.5-100 Hz and its

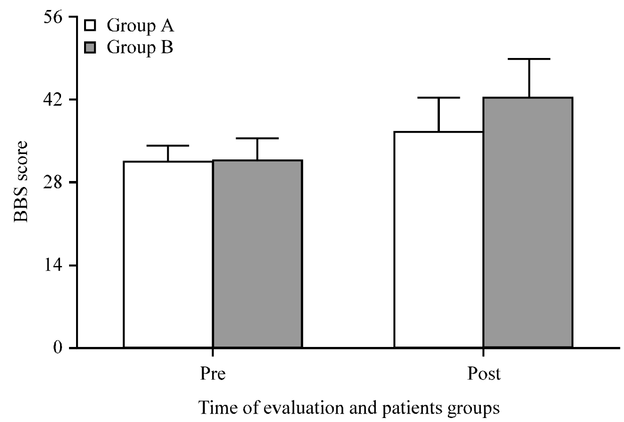

Fig. 1: Mean±SD of Berg's BS score pre and post treatment of the two groups (A, B)

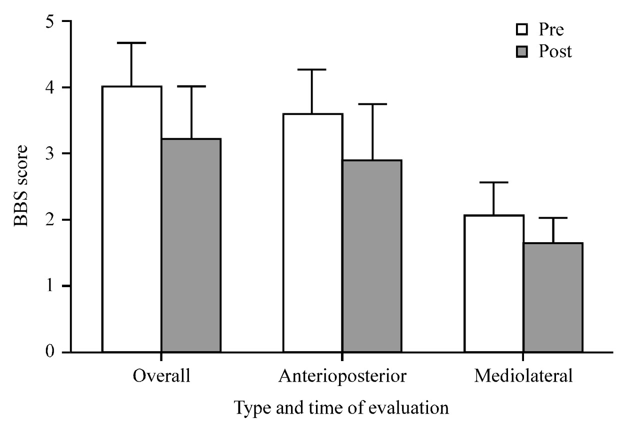

Fig. 2: Mean±SD of stability index at level 8 pre and post treatment of the group (B)

intensity is displayed in percentage from 5-100% of the maximum layout of the solenoid used; the maximum intensity in G depending on the solenoid used "transcranial solenoid maximum intensity is 80 G".

Statistical analysis

Data collection: The collected data was statistically analyzed using SPSS software for medical statistics. The data were collected before and after three months of treatment program for both groups. The significance level was set at ($p<0.05$).

Data analysis

Descriptive statistics: Mean and standard deviation of each group was calculated for each variable pre and post treatment.

Inferential statistics: Comparing mean values of pre and post treatment within the same group was done by paired t-test while comparing mean values of each variable between the two groups was done by unpaired t-test.

RESULTS

Table 1 shows the independent t-test results for the Berg's BS score pre and post treatment between the two groups A and B. There was no significant difference in pre-treatment values where the t-value was 0.408 and p-value was 0.685. While there was a significant difference in the post treatment values ($p<0.05$) where the t-value was 2.935 and p-value was 0.0056. The percentage of difference between groups was 16.26% in favor of the study group.

The results of the present study after the suggested period of treatment showed significant improvement in the measuring variables of both control and study groups when comparing their pre and post treatment mean values. However, more improvement with significant difference was noticed in the study group when comparing the post-treatment mean values of the study group against the control group.

Significant differences were reported when comparing the pre and post treatment means values of overall stability index (4.015±0.664 and 3.24±0.76), anteroposterior (3.6±0.66 and 2.9±0.85) and mediolateral stability indices (2.09±0.47 and 1.66±0.38) of dynamic balance test within the study group (B) at stability level 8.

Also significant differences were reported when comparing the pre and post treatment means values of overall stability index (5.57±0.93 and 4.65±1.03), anteroposterior (4.75±0.86 and 4.1±0.91) and mediolateral stability indices (3.7±0.65 and 3.08±0.87) of dynamic balance test for the same group, the study group (B) but on stability level 5 (Fig. 3).

Table 1: Independent t-test between groups A and B for Berg's BS score pre and post treatment

	Berg's BS score	
Independent t-test	Pre treatment	Post treatment
Mean difference	0.400	5.6500
t-value	0.408	2.9350
p-value	0.685	0.0056
Significance	NS	S

*SD: Standard deviation, P: Probability, S: Significant, NS: Non-significant

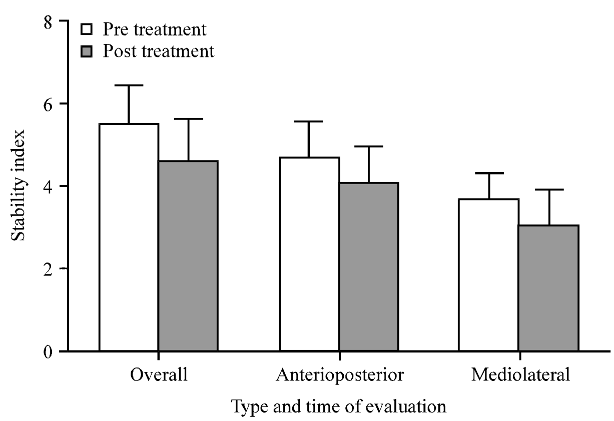

Fig. 3: Mean±SD of stability index at level 5 pre and post treatment of group (B)

DISCUSSION

The current study showed that transcranial magnetic stimulation significantly improve the balance in children with spastic diplegic cerebral palsy. Statistically significant improvement in the measuring variables of both control and study groups when comparing their pre and post treatment mean values. However, more improvement with significant difference was noticed in the study group when comparing the post-treatment mean values of the study group against the control group.

The mean values of overall Stability Index (SI) pre and post treatment for the study group (B) (dynamic balance test at stability level 8) were 4.015±0.664 and 3.24±0.76, respectively, with mean difference of 0.775 which indicate significant improvement ($p<0.0001$). The mean values of anteroposterior (SI) pre and post treatment were 3.6±0.66 and 2.9±0.85, respectively, with mean difference of 0.705 which indicate significant improvement ($p<0.001$). The mean values of mediolateral (SI) pre and post treatment were 2.09±0.47 and 1.66±0.38, respectively with mean difference of 0.43 which indicate significant improvement ($p<0.0001$).

The mean values of overall Stability Index (SI) pre and post treatment for the study group (B) (dynamic balance test at stability level 5) were 5.57±0.93 and 4.65±1.03, respectively with mean difference of 0.92 which indicate significant improvement ($p<0.0001$). The mean values of anteroposterior (SI) pre and post treatment were. 4.75±0.86 and 4.1±0.91, respectively, with mean difference of 0.63 which indicate significant improvement ($p<0.0002$). The mean values of mediolateral (SI) pre and post treatment were 3.7±0.65 and 3.08±0.87, respectively with mean difference of 0.62 which indicate significant improvement ($p<0.0001$).

This comes in agreement with the result of Bennett *et al.* (2005), when they studied both standing and sitting balance in children with CP. They have noted that these children show a reversal of the normal distal to proximal muscle response patterns and excessive co-activation of gastrocnemius and tibialis muscles during leaning forward and backward direction in response to support surface perturbations and they concluded that the muscle response pattern differences for balance control in children with CP are due to CNS deficits and biomechanical changes in their postural alignment.

In the current study significant differences were reported when comparing the pre and post treatment means values of overall stability index (4.015±0.664 and 3.24±0.76), anteroposterior (3.6±0.66 and 2.9±0.85) and mediolateral stability indices (2.09±0.47 and 1.66±0.38) of dynamic balance test within the study group (B) at stability level 8.

This comes in agreement with Shumway-Cook (2007), who reported that, the ankle strategy is considered to be one of the main possible strategies for preventing a fall in the event of a destabilizing perturbation. It was suggested that balance control responses involve a combination of ankle and hip strategies and the selection of a specific balance response appears to be depend mainly on biomechanical variables such as strength and reaction time.

Also significant differences were recorded when comparing the pre and post treatment means values of overall stability index (5.57±0.93 and 4.65±1.03), anteroposterior (4.75±0.86 and 4.1±0.91) and mediolateral stability indices (3.7±0.65 and 3.08±0.87) of dynamic balance test for the same group the study group (B) but on stability level 5. This could be attributed to the beneficial effect of training routine on improving hip strategy which is an important component of postural control which operates mainly during severely disturbed balance activity.

These results show a significant difference in improvement of spastic diplegic cerebral palsy children balance who were treated by balance training in addition to application of transcranial magnetic stimulation in the study group (B) as compared with balance training only in the control group (A).

This finding comes in agreement with Uy and Ridding (2003) who reported that, Transcranial Magnetic Stimulation (TMS) has been shown to directly modulate neuroplasticity in adults with effects that last minutes to days to months. Since the pediatric brain is thought to be significantly more plastic than the adult brain, TMS therapy could result in neuroplasticity changes that may be longer lasting.

This comes in agreement with Heide *et al.* (2006) who showed that repetitive TMS altered levels of excitability of both the infarcted and non-infarcted hemispheres in children with hemiplegic cerebral palsy when applied on contralateral hemisphere.

Takeuchi *et al.* (2005), concluded that high frequency rTMS applied directly to the motor cortex had facilitatory effect. It increased the corticomotor excitability in the stimulated hemisphere and enhanced the short-term motor function in healthy individuals, and patients with neurological disease.

Treatment with rTMS can change excitability of the human cortex for at least several minutes. It can influence the metabolic rate of the stimulated cortex area. The rTMS treatment may lead to functional change in the paretic hand (Schabrun *et al.*, 2008).

CONCLUSION

From the obtained results of this study supported by the relevant literature, it can be concluded that application of transcranial magnetic stimulation for 15 min at 15 Hz frequency can improve balance and postural stability in children with spastic diplegic cerebral palsy. Uses of this application can be added to the balance training program to assist in rehabilitation of children with spastic diplegia.

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