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Effect on Functional Performance of Upper Extremity in Spastic Cerebral Palsy Children Employing Varying rTMS Pulses

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Abstract—*Repetitive Transcranial magnetic stimulation (rTMS) is a new interventional approach used in the diagnosis and treatment of neurological disorders showing encouraging results in motor disorders. Cerebral palsy is one such motor disorder that limits the movement due to tightness in the muscles in a developing child. Spastic cerebral palsy (sCP) patients are not able to perform activities of daily living due to restricted movement of upper and lower extremities. Recent studies have reported that rTMS combined with physical therapy is effective in improving motor functions in these patients. Thus, this study was designed to evaluate the effect of varying rTMS pulses for functional performance of upper extremity in sCP patients. In this study, twenty four sCP patients were selected and divided equally into three group namely, P1500, P2000 and P2500 based on different rTMS pulses to be administered. Constant rTMS frequency of 10 Hz was delivered to each patient followed by 30 minutes of physical therapy daily for 4 weeks. The pre-post assessment of quality of upper extremity skills test (QUEST) for functional performance and modified ashworth scale (MAS) for measurement of spasticity was used as outcome measures. MAS scoring for upper extremity was performed on three muscles namely bicep, supinator and wrist extensor. The pre versus post QUEST scores of all the groups showed statistically significant result ($p<0.05$) with functional improvement of 2.86% in P1500 group, 3.29% in P2000 and 6.80% in P2500 group. In MAS, maximum reduction in muscle spasticity was observed in P2500 patients with statistically significant result in all the three muscles whereas minimum reduction was observed in P1500 patients. The result of this study demonstrated that rTMS pulse of 2500 lead to better functional performance in hand function as compared to 2000 and 1500 pulses in limited number of therapy sessions.*

1. INTRODUCTION

Repetitive Transcranial magnetic stimulation (rTMS) is a non-invasive brain stimulation technique often used for investigating brain functions and their interconnections [1]. The rTMS technique is based on the mechanism of time varying magnetic fields that generates eddy currents in biological tissues and discharges the electric current as brief magnetic pulse through the coil which helps in neural depolarization by increasing metabolic activity of brain tissue, neurons and central nervous system. rTMS has proved to be a useful therapeutic tool in improving motor functions by stimulating the motor cortex area of the brain in adults as well as in children suffering from movement related disorders [2]. The beneficial effect of it is well demonstrated in our previous studies with spastic cerebral palsy patients [3, 4].

Spastic cerebral palsy (sCP) is a one of the common neurodevelopmental disorder seen in pediatric population. Though the incidence of CP remains 2 to 3 per 1000 live birth, there is an increase in the number of cases of CP seeking remedial aids due to increased awareness and internet based guidance [5]. There are several known causes of spasticity such as improper signaling from the central nervous system, traumatic brain injury and stroke [6]. Spasticity itself is a disability persisting in the muscles, however if it is untreated it becomes permanent deformity leading to damage in joint mobility upto end range of movement. Some muscle relaxant medication such as beclofen, tizanidine, botulinum toxin or diazepam may help to reduce spasticity [7] to certain extent for relatively short periods per dose. The only mainstay therapy till date remains physical therapy for the treatment of sCP that shows functional gain in the activities of daily living. sCP presents itself in different forms, namely – hemiplegic, diplegic and quadriplegic that affects the limbs. The purpose of this study was to evaluate functional improvement of upper extremities in sCP patients.

2. MATERIAL AND METHOD

2.1 Material

In this study, Neuro-MS/D Variant-2 (Neurosoft, Ivanovo, Russia) therapeutic modality with cooled angulated coil (AFEC-02-100-C) assembled in a Fig. of eight was used. This magnetic coil was shaped to produce 4 Tesla magnetic fields at the center of stimulation coil. This coil consists of two

circular coils that help to pass the current in opposite direction between the different loops with summation at the point of their intersection [8].

2.2 Participants

Diagnosed cases of sCP between 2 – 15 years of age were selected for this study. The inclusion criteria followed was – their willingness to participate in the study and spasticity on Modified Ashworth scales not less than 1 in upper extremity. Patients with any metallic implant, undiagnosed cases of spastic CP, age below 2 and more than 15 years and uncontrolled seizures were excluded. Twenty four patients from outpatient department of UDAAN-for disabled, Delhi that reported for the treatment of increased muscle tone and limited functional performance of upper extremity, were equally divided into three groups namely, P1500 (mean age 7.3 SD 3.11), P2000 (mean age 6.7 SD 3.61) and P2500 (mean age 8.0 SD 2.83) based on different rTMS pulses to be administered.

2.3 Assessment Scales

Quality of upper extremity skills test (QUEST) and Modified Ashworth scale (MAS) were used as assessment scales for this study. QUEST was designed and developed to specifically overcome the limitations of hand function in CP patients. It evaluates the quality of upper extremity function in five domains: dissociated movement, grasp, posture, protection extension and weight bearing. It is one of the reliable and valid measurement tools to evaluate the effects of any therapy on motor function of upper extremity. It is designed to be used with children who have neuromotor dysfunction with spasticity [9].

Modified Ashworth Scale (MAS) is the tool used for measuring the muscle tone in neurodevelopmental disease. It is clinically approved scale for measuring the spasticity in spastic CP patients [10]. It is score based scale that grades the spasticity from 0-4 in MAS. MAS have 0, 1, 1+, 2, 3 and 4 grades. Zero (0) represents normal muscle tone, 1; slight increase in muscle tone manifested by a catch and release or by minimal resistance at the end of the range of motion when the affected part(s) is moved in flexion or extension, 1+ ;slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of the ROM, 2; more marked increase in muscle tone through most of the ROM, but affected part(s) easily moved, 3; considerable increase in muscle tone, passive movement difficult and 4; affected part(s) rigid in flexion or extension. Modified MAS was used with different scoring for the ease of calculation.

2.4 Study design

This study was conducted after approval from the Institutional Ethics Committee for Human Samples or Participants (IECHSP), North Eastern Hill University, Shillong, Meghalaya. Pre assessment of QUEST and MAS was performed by physician before starting the therapies. rTMS frequency of 10Hz was administered to the patients with 1500 pulses to P1500 group, 2000 pulses to P2000 group and 2500 to P2500 group. These pulse durations were chosen based on our previous studies with 1500 pulses [3, 4]. The rTMS therapy was followed by physical therapy of thirty minutes duration daily for 4 weeks (5 days a week). After 20 session of the therapy, post assessment of QUEST and MAS was performed on all the patients by physicians for statistical analysis.

3. STATISTICAL ANALYSIS

Paired sample *t* – test was performed on the mean values of QUEST and MAS scores of upper limbs, to evaluate significant changes in different treatment groups. Changes in the mean and median values of pre versus post assessment scores was calculated to demonstrate the effect of the therapies employed. Alpha value of 0.05 was considered statistically significant and all the analysis was performed using SPSS 20.0 (IBM Inc., Chicago, USA).

4. RESULTS

The results of both the assessment scales are described below.

4.1 Evaluation of hand function

The evaluation of hand function of all groups (P1500, P2000 and P2500) was performed using QUEST score which is summarized in Table 1. The result was statistically significant with $p<0.05$, thus showing the effectiveness of rTMS therapy. The improvement in hand function was demonstrated by the change in mean scores and relative changes in the median values of all the three groups (Fig. 1). An improvement of 2.86% was observed in P1500, 3.29% in P2000 whereas 6.80% improvement was seen in P2500 group.

Table 1: Changes in QUEST scores of different groups

Group		Median	Mean	SD	*p*
P1500	*Pre*	70.47	67.68	16.90	0.041
	Post	74.75	70.55	18.23	
P2000	*Pre*	88.89	95.30	38.02	0.047
	Post	92.50	100.00	29.55	
P2500	*Pre*	47.73	57.71	36.21	0.015
	Post	57.07	64.51	22.53	
p<0.05 taken as statistically significant					

From these results, it can be observed that 2500 rTMS pulses induce better functional gain in hand functions as compared to lower pulse rate.

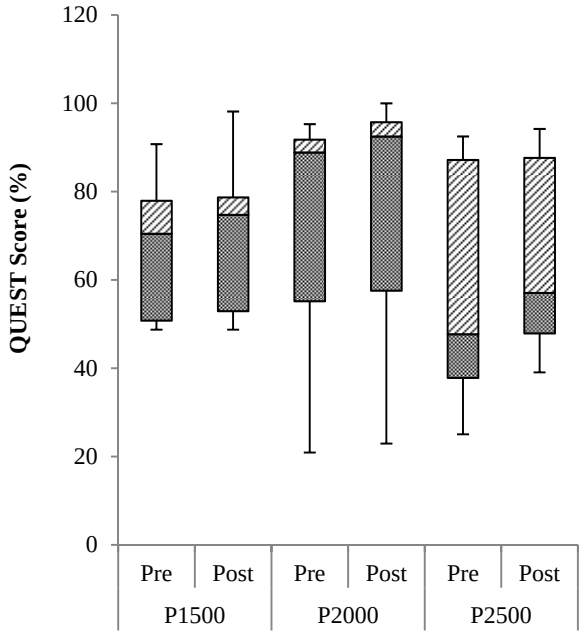

Fig. 1: Box-plot showing changes in median values of QUEST scores and range of improvement in hand function.

4.2 Evaluation of muscle spasticity

Spasticity of upper extremity muscles (biceps, supinator and wrist extensor) was evaluated by MAS for all the groups (Table 2). MAS scores showed statistical significant results in all the three muscles of P2500 group and supinator muscle of P2000 group (p<0.05) but no such changes was observed in P1500 group. This signifies the beneficial effect of rTMS pulses. Additionally, the change in mean scores of MAS showed reduction in muscle spasticity in all the therapy groups but significant changes was observed in P2500 group as compared to other groups. This demonstrated that rTMS pulses of 2500 induce better reduction in muscle spasticity in limited number of sessions as compared to other pulses delivered. Here it can be concluded that reduction in muscle tightness of upper limbs are directly related to the increase in QUEST scores that depicts percentage of functional gain in hand function.

Table 2: MAS results of upper extremity muscles.

Groups		*Pre*	*Post*	*Change*	*p*
	Left hand muscles				
P1500	Bicep	0.88	0.50	-0.38	0.08
	Supinator	1.38	1.00	-0.38	0.20
	Wrist Extensor	0.38	0.25	-0.13	0.35
P2000	Bicep	1.00	0.71	-0.29	0.17
	Supinator	1.29	0.71	-0.57	**0.03**
	Wrist Extensor	1.00	0.57	-0.43	0.20
P2500	Bicep	1.13	0.50	-0.63	**0.04**
	Supinator	1.50	1.00	-0.50	**0.03**
	Wrist Extensor	1.13	0.38	-0.75	**0.04**
	Right hand muscles				
P1500	Bicep	0.88	0.75	-0.13	0.35
	Supinator	2.00	1.38	-0.63	0.09
	Wrist Extensor	0.63	0.25	-0.38	0.20
P2000	Bicep	1.00	0.71	-0.29	0.17
	Supinator	1.14	0.43	-0.71	**0.04**
	Wrist Extensor	0.43	0.29	-0.14	0.36
P2500	Bicep	1.13	0.63	-0.50	**0.03**
	Supinator	1.38	0.75	-0.63	**0.04**
	Wrist Extensor	0.75	0.25	-0.50	**0.03**

p<0.05 taken as statistically significant

5. CONCLUSION

This study demonstrated the effectiveness of rTMS in general and the varying effect of different pulses on the spastic muscles of upper extremity. Those patients who were administered higher rTMS pulses (P2000 group) showed appreciable gain in the QUEST and MAS scores as compared to those patients that were provided lower number of pulses. Functional improvement as of QUEST score was 6.80% in P2500 group, 3.29% in P2000 groups and 2.86% in P1500 patients. The improved hand function in these children must be attributed to the stimulating effect of the magnetic pulses delivered from the rTMS coil on the motor cortex area of the brain that led to the activation of related muscles which otherwise might had been dormant. Additionally, it was observed that rTMS pulse of 2500 worked on all the hand muscles in comparison to lower pulse rate. It can be noted that better functional performance of upper extremity was a result of reductions in related muscle tightness induced by the rTMS.

6. ACKNOWLEDGEMENTS

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