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ASSESSMENT OF EFFECTS OF NEUROMUSCULAR ELECTRICAL STIMULATION OF TIBIALIS ANTERIOR ON THE QUALITY OF LIFE IN POST STROKE PATIENTS

Physical Medicine & Rehabilitation

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ABSTRACT

Background and Purpose: Effect of neuromuscular electrical stimulation in acute stroke patients while stimulating only single muscle is not known. The purpose of the study is to find the influence of early neuromuscular electrical stimulation to the motor point of tibialis anterior muscle in achieving improvement of QoL through early motor control of the ankle in post stroke patients. **Methods:** One hundred and thirty-two subjects were selected between 45-65 years of age and within 2 weeks of the first attack of stroke. They were randomly divided into study and control groups comprising 66 subjects in each group. Study group received neuromuscular electrical stimulation to tibialis anterior muscle of the affected limb, 15 minutes twice daily, 5 days a week upto 3 weeks along with conventional exercise therapy whereas control group received only exercise therapy for that period. Outcome measures include the 4 domains of the WHOQOL BREF questionnaire viz. physical health, psychological health, social relationships and environment. They were recorded before starting treatment, after 3 weeks and at 7 weeks following starting the treatment. **Results:** Significant improvement of Quality of Life in the domains of Physical health, Psychological health and Environment following Neuromuscular Electrical Stimulation (NMES) was noted in the study group. No significant improvement in the domain of Social relationships was noted. **Conclusion:** Neuromuscular electrical stimulation along with traditional exercise programme is superior to exercise alone for improvement of QoL in post-stroke patients.

KEYWORDS

Stroke, Spasticity, Quality Of Life, Neuromuscular Electrical Stimulation, Tibialis Anterior

INTRODUCTION

Stroke is one of the most debilitating non-communicable diseases. World Health Organisation (WHO) defines stroke as "rapidly developed clinical signs of focal disturbance of cerebral function; lasting more than 24 hours or leading to death, with no apparent cause other than vascular origin".[1] The morbidity profile of stroke includes coma, hemiplegia, monoplegia, nerve paresis, cognitive dysfunction, memory loss, bladder and bowel dysfunction, hemianesthesia, hemianopia, dysphagia, aphasia, neglect syndrome, visuo-spatial deficit etc. Of this hemiplegia contributes about 90% of patients.[1] Eighty percent of post stroke patients have some locomotor function but many have significant gait deficit.[4] Early stage training is more effective for motor recovery and functional recovery is inefficient if interventions start after 5 months of post stroke.[2,3]

Neuromuscular electrical stimulation is one of the frequently tested modalities in motor recovery of stroke patients. The first single-channel surface peroneal nerve stimulator to provide ankle dorsiflexion during the swing phase of gait for stroke survivors was first described by Lieberson and associates. In the upper limb, its usefulness is well documented. However, we have come across only a few studies where functional electrical stimulation was used to influence early motor recovery of the lower limb.[4,5,6,7] Some studies reported that it has no advantage over conventional therapy.[8,9] Therefore, the role of neuromuscular electrical stimulation for early motor recovery and ambulation in post stroke patient is still controversial.

After stroke extensor synergy dominates in the lower limb. This results in plantar flexion attitude of ankle, which in turn leads to compensatory circumduction gait, disturbance in balance during gait and maintenance of posture while standing. Therefore, improvement of ankle dorsiflexor motor control may improve this condition by reducing plantar flexor spasticity, increasing dorsiflexor strength and reducing plantar flexor attitude in both stance and swing phase of gait.[10]

Most of the studies for lower limbs were on chronic stroke patients, some stimulated acupuncture points and most of the studies used Functional electrical stimulation (FES) not neuromuscular single muscle stimulation. Therefore the question arises, if isolated neuromuscular electrical stimulation of the tibialis anterior muscle may influence early recovery motor control of ankle in post stroke patients in terms of decrease in ankle plantar flexor spasticity and increased in dorsiflexors strength with a decreased in antagonistic co-contraction.[4,6]

This study was contemplated to find the role of neuromuscular electrical stimulation of the lower limb muscles on Quality of Life in post stroke patients. In many rehabilitation centres, only exercises are advised to stroke patients till now. Electrical stimulation is a simple, affordable and easily available therapeutic physical modality for stroke recovery with minimum or no adverse effects. Use of neuromuscular electrical stimulation along with exercise therapy can speed up motor recovery in stroke patients. Thus, it improves quality of life of the patients, reduces burden of impairment and disability, increases productivity.

MATERIALS AND METHODS

The study was a prospective, randomized controlled study, conducted in the Department of Physical Medicine and Rehabilitation, in a tertiary care hospital of eastern India for the period of two years. Post stroke patients within 2 weeks of the first acute stroke attack admitted in the Physical Medicine and Rehabilitation Ward for rehabilitation management were taken for the study. Inclusion criteria for the study were confirmed cases of stroke by Computerized Tomography, independent in daily activities before stroke, having at least some visible voluntary movement in hip, knee and ankle (Medical Research Council Grade-2), age between 45 and 65years. Exclusion criteria were medically unstable patient, repeated attacks of stroke (>1 attack), patient with flaccid lower limb, unable to walk before stroke due to some other causes, any neuromuscular disease present before stroke, brain stem or cerebellar lesion, patients with cardiac pacemaker, cognitive dysfunction, aphasia.

Sample Size:

A sample size of 59 in each group was calculated based on effect size of 20% with 10% early recovery in conventional exercise group at 5% significance level and 80% power. Adding 10% drop out; a final sample of 66 in each group had been considered.

Method of Recruitment

After getting informed consent, patients were allocated into two groups by using a block randomization technique. To minimize uneven distribution of the known variables, stratification of the variables were done.

Study Variables-
Age, Sex, aetiology of stroke - Ischaemic vs Haemorrhagic, paretic side - Right vs Left, site of lesion in the brain

Outcome Variables
Outcome measures include the 4 domains of the WHOQOL-BREF questionnaire viz. physical health, psychological health, social relationships and environment.

A conventional exercise includes neurodevelopmental training, stretching of spastic or tight muscles and maintaining range of motion of joints of the affected part.

Procedure
The study population was selected after taking informed consent. The study population was divided into study and control groups. The study group received both conventional hemiplegic exercise programme and electrical stimulation to be affected lower limb and the control received only the conventional exercise programme. To the study group, surged Faradic current was delivered to the motor point of tibialis anterior muscle twice a day, 15 minutes each time for 5 days a week up to 3 weeks.

The outcome variables were measured before starting the interventions and at 3 weeks and at 7 weeks of the initiation of the intervention for both the groups.

RESULTS
There was no difference in baseline characteristics between the study and control group (Table 1).

Table 1: Comparison of baseline characteristics between study and control groups:

Variables	Study n= 66		Control n= 66		p- value
Age (Years)	55.64±6.70		56.89±7.25		0.303
Sex	Male	42	Male	40	0.772
	Female	24	Female	26	
Type of stroke	Infarction	44	Infarction	50	0.100
	Haemorrhage	18	Haemorrhage	16	
	Both	4	Both	0	
Site of affection in brain	MCA	56	MCA	60	0.290
	Outside MCA	10	Outside MCA	6	

MCA: Middle cerebral artery, $p< 0.05$: significant

Quality of Life (QoL) data collected from the WHOQOL-BREF questionnaires show a marked improvement in the domains of Physical health, Psychological health and Environment of the patients in the study group who received electrical stimulation as compared to those in the control group. (Figs.1,2,4) The rate of improvement was more marked at 3 weeks in the domains of Physical and Psychological health than at 7 weeks.(Figs. 1,2)

The domain of Psychological health also shows a decrease in the values in the patients who have not received electrical stimulation as part of their rehabilitative management at 7 weeks compared to the values at 3 weeks. (Fig.2) The domain of Social relationship does show an improvement at 3 weeks in both the groups but also shows a decrease in both at 7 weeks.(Fig.3)

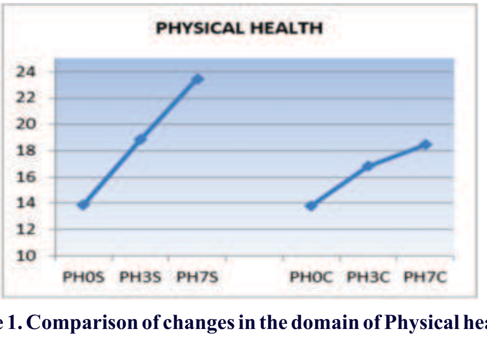

Figure 1. Comparison of changes in the domain of Physical health

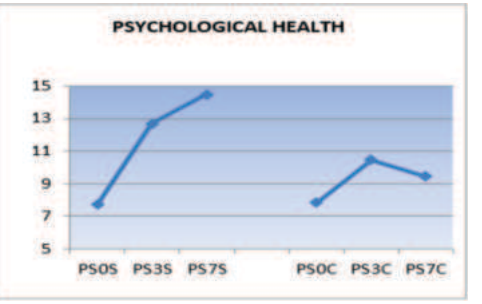

Figure 2. Comparison of changes in the domain of Psychological health

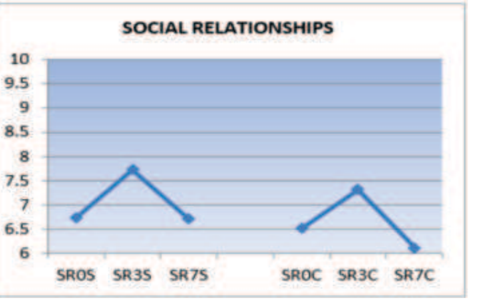

Figure 3. Comparison of changes in the domain of Social Relationships

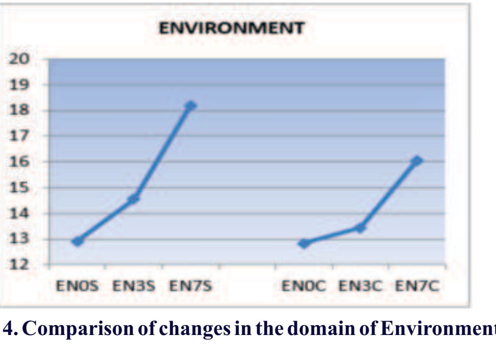

Figure 4. Comparison of changes in the domain of Environment

DISCUSSION
Clinical NMES systems stimulate either the nerve directly or the motor point of the nerve proximal to the neuromuscular junction. The threshold for eliciting a nerve fibre action potential is 100 to 1,000 times less than the threshold for muscle fibre stimulation. The nerve fibre recruitment pattern mediated by NMES follows the principle of "reverse recruitment order" wherein the nerve stimulus threshold is inversely proportional to the diameter of the neuron. It preferentially recruits type II muscle fibres. NMES is delivered as a waveform of electrical current characterized by stimulus frequency, amplitude and pulse width. Frequency range for NMES systems is 10–50 Hz. Ideal stimulation frequencies range from 12–16 Hz for upper-limb applications and 18–25 Hz for lower-limb applications.[11]

Neuromuscular electrical stimulation can improve neuroplasticity by the following mechanism;

1. Increase of synaptic efficacy in existing neural circuits or formation of new synapses. This can be explained by as follows;
   (a) Electrical stimulation to muscles causes contraction of that particular muscle and leads to movement of joins and the limb. This sends proprioceptive inputs to brain and reinforce network connection patterns through formation of new synapses which ultimately induces cortical reorganization (studied in monkey).
   (b) Electrical stimulation to skin expands cortical representation.[4]
2. Another mechanism that helps in early motor recovery is reduction of spasticity. The possible mechanisms are;
   (a) Presynaptic inhibition of hyperactive stretch reflexes in spastic muscle
   (b) Direct inhibition of an abnormally excited nerve
   (c) Disinhibition of descending voluntary command to the motor neurons of the paretic muscles ultimately results in decrease in co-contraction of spastic antagonist.[6]

Yan T and co-workers[6] conducted a randomized placebo controlled trial in acute stroke patients to find out the effectiveness of functional electrical stimulation for early motor recovery and walking ability. They stimulated hamstring, quadriceps, tibialis anterior and medial gastrocnemius for 3 weeks. They found positive result in terms of improvement in composite spasticity score, maximum isometric voluntary contraction of ankle dorsiflexors and plantarflexors and walking ability. Our study was also done on acute stroke patients but we applied neuromuscular electrical stimulation only in tibialis anterior muscle to gain early motor recovery in ankle joint. We found it quiet impressive in terms of early recovery of ankle motor control in compared to traditional exercises alone.

Mesci N and co-workers[12] did a similar study on chronic stroke patients and found neuromuscular electrical stimulation superior than conventional rehabilitation programme for the improvement of ankle dorsiflexor motor power and reducing plantarflexor spasticity. Our study showed similar findings improved QoL in acute stroke patients.

Sabut Sk[13] concluded from their study that therapy combining FES and conventional rehabilitation programme was superior to a conventional rehabilitation program alone, in terms of reducing spasticity, improving dorsiflexor strength and lower extremity motor recovery in stroke patients. In the study they stimulated the tibialis anterior and peroneal nerve whereas, we stimulated the tibialis anterior muscle only to acute stroke patients to get early ankle motor control.

Yavuzer et al[8] did a randomized controlled, triple blinded trial with 25 post stroke patients with mean age 55 years and without volitional ankle dorsiflexion. Neuromuscular electrical stimulation was given to the study group 5 days a week for 4 weeks to tibialis anterior muscle of paretic limb. In this study, neuromuscular electrical stimulation was not found superior to conventional rehabilitation therapy. Brunnstrom stages improved significantly in both groups ($p<0.05$). In total, 58% of the NMES group and 61% of the control group gained voluntary ankle dorsiflexion. Between-group difference of percentage change was not significant ($p<0.05$). Gait kinematics was improved in both groups, but the difference between groups was not significant.

Our study was performed on 132 patients suffering from hemiplegia due to cerebrovascular accident within 2 weeks of attack. This study showed significant improvement of Quality of Life in the domains of Physical health, Psychological health and Environment following Neuromuscular Electrical Stimulation (NMES) of tibialis anterior muscle of the affected limb in comparison to conventional therapy group.

There was no significant improvement in the domain of Social relationships in either group. NMES was well tolerated in patients and there was not any report of any type of adverse effects.

Poor prognostic factors are usually not present in our study population resulting in good recovery. This study shows that early rehabilitation has a great role in stroke recovery and consequently in the Quality of Life. Study limitations are small sample size, less duration of therapy, few assessment tools. Thus, future studies with bigger sample size, longer duration of therapy and with multiple standardized assessment tools to gain unbiased results are recommended.

CONCLUSION

The primary aim of our study was to assess the effects of Neuromuscular electrical stimulation of Tibialis anterior on the Quality of Life in Post stroke patients. The data collected from the study indicates a significant increase in QoL across the domains of Physical and psychological health and environment.

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Conflicts of interest
There are no conflicts of interest

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