Original Article

APPLICATION OF TRANSCUTANEOUS ELECTRICAL STIMULATION ON LOWER LIMB ACUPOINTS AS AN IMPORTANT ADJUNCTIVE TOOL IN STROKE REHABILITATION PROGRAM & ITS EFFECTS ON SPASTICITY AND FUNCTIONAL ABILITY

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ABSTRACT

Background: There is increasing evidence of neural plastic changes associated with specific training that is goal-directed and requires special attention with practice. Sensory input by Transcutaneous electrical stimulation (TENS) on acupoints and task related training (TRT) induces recovery of lower limb function in patients after stroke. There are very few studies which show the effectiveness and importance of sensory stimulation through acupoints, therefore the purpose of the current study is to evaluate the effectiveness of TENS on acupoints when applied with other rehabilitation program on reducing spasticity and improving lower limb function in subjects after sub-acute stroke. **Materials and Methods:** Thirty subjects with sub-acute stroke of either side including both male and female participated in randomised clinical trial. Both group received TRT along with conventional physiotherapy program. TENS on acupoints was given in subjects of experimental group along with TRT and conventional program to evaluate the effectiveness of TENS. Measurement of spasticity was done by Modified Ashworth Scale (MAS), functional ability was measured by Dynamic Gait index (DGI) and Timed up & Go (TUG) test. All the measurements were done before and after 5 weeks intervention. **Result:** A significant reduction in spasticity measured by MAS ($p=0.03$) and relevant improvement in functional ability measured by DGI ($p=0.03$) and TUG ($p=0.04$) were observed in experimental group after five weeks intervention. **Conclusion:** Present study provides an evidence to support the use of TENS on acupoints as an adjunctive tool with task related training and other rehabilitation program.

KEY WORDS: Transcutaneous Electrical Stimulation (TENS); Acupoints; Sub-acute stroke rehabilitation.

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Access this Article online

Quick Response code

International Journal of Physiotherapy and Research
ISSN 2321- 1822
www.ijmhr.org/ijpr.html

Published: 11 August 2013

Received: 14 June 2013

Accepted: 20 June 2013

INTRODUCTION

Stroke is the leading cause of adult disability and inpatient rehabilitation admissions.[1] It is the second commonest cause of death and fourth leading cause of disability world wide.[2] Approximately 20 million people each year will suffer from stroke and of these 5 million will not survive. In India, the ICMR estimates in 2004 indicated that stroke contributed 41% of deaths and 72% of disability adjusted life years amongst the non-communicable diseases.[3]

Ambulation and locomotion is an essential part of daily activity in life. After stroke, about 65% of survivors have reduced ambulatory capacity and after 6 months 50% still have impaired muscle function. Intramuscular changes which leads to impaired locomotion and functional capacity results from damage of motor and sensory pathways.[4-6]

In patients after stroke because of spasticity ankle dorsiflexors of affected limb become weak and it leads to some compensation in normal gait pattern such as foot slap, toe dragging, and step gait. Weak dorsiflexors are one of the most common causes to loss of joint coordination & gait dysfunction. Motor weakness, poor motor control, and spasticity result in an altered gait pattern, poor balance, risk of falls, and increased energy expenditure during walking. Ineffective ankle dorsiflexion during swing (drop foot) and failure to achieve heel strike at initial contact are common problems that disturb gait pattern after stroke. Voluntary ankle dorsiflexion in the lower extremity is a stand point indicating the achievement of selective motor control.[8]

There are a number of different approaches to physiotherapy treatment following stroke. Prior to the 1940s these primarily consisted of corrective exercises based on orthopaedic principles related to the contraction and relaxation of muscles, with emphasis placed on regaining function by compensating with the unaffected limbs. In the 1950s and 1960s techniques based on available neurophysiological knowledge were developed, including the methods of Bobath, Brunnstrom, Rood and the Proprioceptive Neuromuscular Facilitation approach. In the 1980s the potential importance of neuropsychology and motor learning was highlighted and the motor learning, or re-learning, approach was proposed. This suggests that active practice of context-specific motor tasks with appropriate feedback would promote learning and motor recovery.[9]

Task-related training (TRT) is a rehabilitation strategy that involves the practice of goal-directed, functional movements in a natural environment to help patients derive optimal control strategies for alleviating movement disorder.[10] Task-specific physiotherapy involving repetitive practice of meaningful daily activities can lead to increased activation of the affected sensory-motor cortex.[11] Studies also demonstrate that movement and experience-dependent reorganization patterns occurs in both the damaged hemisphere and the contralateral hemisphere.[12,13] There is strong evidence that task-specific gait training improves gait post-stroke.[14,15]

There is increasing evidence of neural plastic changes associated with training. Cortical representation areas can be increased by training that is specific, requires attention, and is repeated over time and also by sensory input.[16] Sensory information to the brain is provided by sensory tracts via various modalities. One way to maximize the amount of sensory input is via sensory amplitude electrical stimulation, which, unlike neuromuscular electrical stimulation, is not limited by muscle fatigue. In one study, when sensory stimulation was delivered to the hand of subjects without neurological impairments, functional MRI showed increased blood flow in the areas of the primary and secondary motor cortices as well as the primary sensory cortex. In other studies, the application of sensory stimulation to patients following a stroke resulted in improvements in skin sensation and sensory evoked potential, a reduction in abnormally high muscle tone and also reduced inattention and neglect.[17-21]

Transcutaneous electrical nerve stimulation (TENS) has been used to treat pain and also chronic hemiplegia since the last decade.[10] In clinical practice, the TENS electrodes are commonly placed at 4 broad categories of anatomical sites, including over the painful areas, along the peripheral nerves, along spinal nerve roots, or other specific points like acupoints. The study done by Shamay and Christina showed that application of TENS on acupoints combined with TRT results decreased impairment and improve functional ability in individual after chronic stroke.[22] Subsequently, Tiebin Yan, and co-workers found that 3 weeks Transcutaneous stimulation over 4 acupuncture points in lower limb for 60 min in acute stroke, significantly decreased ankle plantar flexor spasticity, and increased dorsiflexor strength.[23] On the basis of present evidences it was hypothesised that application of TENS on acupoints may induce additional therapeutic effects with other rehabilitation program in sub-acute stroke. The aim of present study was to support the evidence for use of transcutaneous electrical stimulation on acupoints for stroke rehabilitation.

MATERIAL AND METHODS

The sample of 30 subjects between 40-47 year aged were assessed and selected by the means of simple random sampling from MMIMSR, Mullana, Ambala. Subjects were randomly allocated in the two groups using sealed yellow and green coloured envelopes containing the treatment allocation for each participant. Both male and female participants with unilateral stroke on either side, having the spasticity score between 2 to 4 in MAS were included. All the participants were able to walk 10 m unassisted with or without walking aids. Exclusion criteria for the study were subjects with psychological and cognitive disorders, chronic and secondary stroke, significant visual & auditory impairment, brainstem lesions and cerebellar lesions. 30 subjects were randomly allocated by means of simple random sampling into Control (group A) and Experimental group (group B). The procedure of study was explained to all subjects and written consent was taken. All subjects in both Groups actively participated in the study and received conventional physiotherapy treatment approaches that were aimed at promoting the recovery of postural control (balance during the maintenance of a posture, restoration of a posture or movement between postures). Interventions that had a more generalized stated aim, such as improving functional ability of lower limb and upper limb were also given.

Protocol: In Control group, all participants received Task-related training and conventional physiotherapy program for 60 minutes. In Experimental group, all participants received 60 minutes of TENS on acupoints followed by Task-related training and conventional physiotherapy. Stimulator applied with 0.2 ms pulses, at 100 Hz in the constant mode within the subject's tolerance level, via (5 × 3.5 cm) electrodes attached to the following acupuncture points on the affected lower extremity: St 36, Lv 3, GB 34, and Bl 60. The choice of parameters of TENS, location of acupoints and Task-related training program was adapted by previous studies.[10,22,23] The program was conducted for 60 minutes per session. It included 40 minutes of 4 lower limb task specific exercises with wooden blocks of 10-15 cm in height. The wooden blocks was used for loading, stepping and heel-lift exercise.The total duration of treatment protocol was 5 days a week for 5 week.

Fig.1- Location of acupoints

Outcome measures: Measurements were taken prior and after 5 weeks of intervention in both groups, that was consisted with following measures.

Modified Ashworth Scale (MAS)

The objective measurement of spasticity of planterflexor was done by using MAS scale.[24] The test has recently been validated and shown to be reliable measurement of spasticity on lower limb in subjects with stroke. [25,26] The patients was examined on a couch in relaxed position in supine lying. The affected extremity was moved passively. Resistance encountered by the therapist to passive movement of ankle was then recorded by MAS.

Timed up and Go test (TUG)

The timed up and go test is a simple, quick and reliable functional mobility test that is used to examine the functional mobility and balance in community dwelling, frail older adults and individual with stroke.[27,28] A recent study demonstrate the reliability and validity of TUG test in stroke population.[29,30] The patients was asked to stand up from chair, walks 3 meters, turn around, return to chair and sit down. The time taken to complete the task was recorded in second with help of stopwatch.

Dynamic Gait Index (DGI)

The Dynamic Gait Index (DGI) was developed by Shumway-Cook and Woollacott to evaluate functional stability during gait activities in older people and to evaluate their risk of falling.[31] The DGI is an 8-item tool with which the examiner

rates an individual's gait performance on an ordinal scale that ranges from 0 to 3. It takes approximately 10 minutes or less to complete and score the DGI. Reliability and validity of DGI for people with stroke has been established.[32,33] Test was performed on distance of 20 foot. The patients were instructed to walk on marked surface with different task.

RESULTS

Data analysis was done by using SPSS version 16.0 software. Descriptive statistics were used for subject's demographic characteristics. Non-parametric data were analysed with Man-Whitney U test and Wilcoxon test. Student t-test was used for parametric data.

The p-value was set at 0.05. The mean age of group A was 63.2(4.0) years and that of group B was 62.8(4.5).

There was no significant reduction in spasticity in control group after treatment. Functional improvement was observed in both groups after 5 week intervention (table-1).

The subjects, who received TENS shows significant reduction in spasticity compare to control group (p=0.03). The experimental group was also superior in DGI score (p=0.03) and time taken to complete the task in TUG test (p=0.04). The result of the study shows significant reduction and relevant improvement in functional capacity after 5 week intervention in the subjects who received TENS on acupoints. (table-2).

Table -1: comparison of pre and post values within Group A and B.

	MAS				DGI				TUG(sec.)			
	Group A		Group B		Group A		Group B		Group A		Group B	
	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post
Mean	3	2.7	3.3	2.2	7.1	9.13	7.1	11.4	25.2	23.4	24	20.9
S.D.	0.7	0.5	0.6	0.7	0.9	2.92	0.9		3.1	3.2		3.6
S.E.M.	-	-	-	-	-	-	-	-	0.79	0.82	0.67	0.93
Median	3	3	3	2	7	10	7	12				
IQR	2	1	1	1	2	6	2	2				
Maximum	4	3	4	4	9	14	9	16				
Minimum	2	1.5	2	1.5	6	5	6	8				
Test value	-1.47 (z-value)		-2.98 (z-value)		-2.42 (z-value)		-3.41 (z-value)		2.41 (t-value)		3.29 (t-value)	
p-value	-0.14		(0.003)*		(0.01)*		(0.001)*		(0.03)*		(0.005)*	

* Significant difference between pre and post value within Group A and B.
MAS= Modified Ashworth Scale, **DGI =** Dynamic Gait Index, **TUG** = Timed Up and Go test, **S.D**= standard deviation, **IQR**= Inter Quartile Range, **SEM**= standard Error of Measurement.

Table-2: comparison of pre and post values between Group A and B.

	MAS				DGI				TUG(sec.)			
	Pre		Post		pre		post		pre		post	
	A	B	A	B	A	B	A	B	A	B	A	B
Mean	3	3.3	2.7	2.2	7.1	7.06	9.1	11.4	25.2	24.1	23.4	20.9
S.D.	0.7	0.6	0.5	0.7	0.9	0.9	2.9	2.2	3.08	2.63	3.1	3.6
S.E.M.									0.79	0.67	0.82	0.99
Median	3	3	3	2	7	7	10	12				
IQR	2	1	1	1	2	2	6	2				
Maximum	4	4	3	4	9	10	14	16				
Minimum	2	2	1.5	1.5	6	6	5	8				
Test value	-1.249 (U-value)		-2.14 (U-value)		-0.22 (U-value)		-2.11 (U-value)		1.147 (t-value)		1.98 (t-value)	
p-value	-0.21		(0.03)*		-0.82		(0.03)*		-0.26		(0.04)*	

* Significant difference between Group A and B.
MAS= Modified Ashworth Scale, **DGI** = Dynamic Gait Index, **TUG** = Timed Up and Go test, **S.D**= standard deviation, **IQR**= Inter Quartile Range, **SEM**= standard Error of Measurement.

DISCUSSION

In the present study it was found that spasticity of plantar flexor was reduced significantly after application of TENS on acupoints in group B. The finding of present study is similar to study done by Wong and co-worker which found that application of TENS on acupoints by surface electrode 5 times a week is effective therapy for better neurological and functional outcomes.[34] Study by Gladys and co-workers states that application of TENS on acupoints at 4 Hz; and 0.2ms pulse duration at the tolerable intensity increases negative peak latency (NPL) which indicates that the conduction velocity of nerve had decreased. An increase in H/M ratio and reduction in H-reflex latency in the affected limb in patients with stroke, this indicates that individual suffering from spasticity presents high excitability in pathways involving stretch reflex.[35]

Tiebin Yan and co-workers stated that, when TENS was applied over the acupoints the areas stimulated were much larger than those of acupuncture needles.[23] Gladys investigated that similar effect were found during stimulation by TENS on peripheral and acupoints. However the effect was somewhat greater in acupoints. The effects may be due to specific characteristic that occur at acupuncture points included large peripheral nerve, cutaneous nerves, blood vessels, and motor points. The acupoints are the loci of type II and type III afferents fibres which can be stimulated by TENS.[35] Another hypothesis given by Shamay and Christina suggested that reduction in spasticity after application of TENS on acupoints may be because, enhancement of pre-synaptic inhibition of hyper active stretch reflexes in the spastic muscle and decrease in co-contraction of spastic antagonist.[22]

In present study there was significant improvement in TUG and DGI parameters after intervention in both group and however group B was superior to control group. These findings were similar to study by Catherinel et al which stated that 4 weeks of TRT intervention improves sit to stand performance and reduced time to complete the TUG task.[14] The possible mechanism behind this as suggested by Sung et al may be that brain plasticity occurs after physical intervention which involves repetition of task.

The study demonstrated that the 4 week TRT program can induce functional recovery and sensory cortical reorganization in chronic hemiplegic population.[36]

The finding of present study shows that there is improvement in functional ability in both groups which means specific training along with conventional treatment induces functional changes. Cortical representation area of the paretic muscle was found to be reduced in subjects after stroke; this can be due to limited use of paretic muscle and limb.[37] Joachim et al found that after 12 weeks of Constraint-induced movement therapy CIMT in hand, the cortical reorganization of affected limb significantly occurred. The possible mechanism may be increase in excitability of neuron already involved in innervations of affected muscle or increase in excitable neuronal tissue in infarcted hemisphere. The task specific training involving the functional activity of limb induces new anatomic connection by means of sprouting.[37] The present study also provides the evidence of improvement in functional characteristics associated with significant reduction in spasticity of planterflexors when TENS was given along with TRT and conventional exercise which was specific to lower limb function. The another study support the hypothesis that combined effect of TENS and TRT induces greater improvement in motor function in subjects after stroke.[10,22]

On the basis of present evidences above mechanism might be involved in improvement of lower extremity functions in relation to spasticity, TUG and walking function. However spasticity of other muscle group was not taken into consideration. One of the limitations of study is that, quantitative and laboratory investigation of spasticity and relevant improvement in ankle dorsi flexor was not done.

CONCLUSION

In conclusion, the present study provides an evidence to support the use of TENS on acupoints as an adjunctive with other rehabilitation program. The clinical and statistical improvements were observed after the 5 week intervention. Therefore, TENS on acupoints can be incorporated with other rehabilitation prog-

-ram for effective reduction of spasticity and associated lower limb function improvement in subjects after sub-acute stroke. Although present study was done on small sample size, the finding of study may be generalized to sub-acute stroke patients with larger population.

AKNOWLEDGEMENTS:

Author extending his gratitudes towards the subjects for their voluntary participation in the study and also extending his sense of gratudes to all the Investigators & co-investigators those involved in the similar earlier studies from where the literature has been reviewed for this study.

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How to cite this article:

Manoj Kumar Deshmukh, Chandan Kumar, Manu Goyal. Application of transcutaneous electrical stimulation on lower limb acupoints as an important adjunctive tool in stroke rehabilitation program & its effects on spasticity and functional ability. Int J Physioth Res 2013;03:63-69.