Original Article

THE EFFECT OF TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION (TENS) COMBINED WITH BOBATH ON POST STROKE SPASTICITY. A RANDOMIZEDCONTROLLED STUDY

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ABSTRACT

Objective:

Spasticity is a vital component and one of the diagnostic features of upper motor neuron lesions and syndromes accompanied with it. This abnormal excessive muscle tone can lead to secondary complications such as pain, joint contracture, pressure ulcers and gait disturbance. Studies have reported that electrical stimulation of acupoint is effective in treatment of stroke patients with spastic hypertonia. The aim of this study was to evaluate the effectiveness of combined Bobath-TENS therapy in relation to simple Bobath among patients suffered from stroke and is in the rehabilitation phase of their disease presenting with spastic paralysis.

Methods:

A randomized controlled trial was conducted at the Rehabilitation department of Tongji medical hospital. A total of 30 stroke patients with ankle plantar flexor spasticity were recruited. The mean age of the patients was 55.2 years (range 37-70 years) and the mean duration of stroke was 4.73 months (range 3 to 8 months). The patients were randomly assigned to two groups; 15 patients each were assigned to each group. Patients in the control group received 15 minutes of inhibitory Bobath technique. Patients in the study group received a combination of 30 minutes of TENS on lower leg acupuncture points along with inhibitory Bobath techniques for 4 weeks, 5 days a week. Muscle tonus (MAS) score of the affected ankle, passive ankle joint dorsiflexion range of motion, dorsiflexion strength test, gait speed and the Brunnstrom stages of motor recovery were noted as the final outcome so as to compare the two groups.

Results

The combined therapy study group with TENS-Bobath showed extremely successful results in terms of selected parameters. All the parameters turned out to be statistically significant ($P<0.05$).Ankle passive dorsiflexion movement improved massively followed by 10 meters walk test in the combination therapy group. Although, Bobath only therapy control group was also statistically significant, but the level of significance was much marked in the combined study group.

Conclusion: 20 sessions of TENS combined with Bobath decreased plantar flexor spasticity, improved dorsiflexors strength, and increased gait velocity significantly more than Bobath alone.

Keywords: Rehabilitation, spasticity, stroke, TENS

INTRODUCTION

Spasticity, that has been characterized by an abnormal increased muscle tone at resting condition along with enhanced stretch reflex and tendon jerks is a vital component and one of the diagnostic feature of upper motor neuron lesions and syndromes accompanied

with it[1]. It is most commonly seen clinically among patients presenting with stroke.

Most common symptoms among post-stroke patients associated with spastic paralysis are painful muscle spasms, a series of involuntary rhythmic contractions and relaxations leading to jerking clonus, hyperexcitable reflexes, hypertonia and stiffness in the arms, legs or fingers. In general, spasticity develops when an imbalance occurs in the excitatory and inhibitory input to alpha motor neurons caused by damage to the spinal cord and/or central nervous system. The damage causes a change in the balance of signals between the nervous system and the muscles, leading to increased excitability in the muscles.

This abnormal excessive muscle tone can lead to secondary complications such as pain, joint contracture, pressure ulcers and gait disturbance[2]. Many therapeutic approaches have been used to manage spasticity following stroke including physical therapy, oral medication, electrical stimulation, and surgical intervention[3]. Most commonly, combination of treatment strategies are applied so as to get maximal benefit towards improving the symptoms.

The treatment goal should be first activating contraction of antagonist muscles to provide reciprocal inhibition and lengthen spastic muscles, minimizing highly stressful activities, targeting functional skills and conducting agonist contractions first in small ranges progressing to larger arcs of movement.

Medically, the problem is relieved by using clonazepam, baclofen and dantrolene. The effectiveness of medications varies between individuals, primarily based on location of the upper motor neuron lesion. Injection therapy in the form of Phenol injections can be used, or botulinum toxin injections into the muscle belly, to attempt to dampen the signals between nerve and muscle. Surgery may be needed for a tendon release in the case of a severe muscle imbalance leading to contracture. Selective dorsal rhizotomy has also been used to decrease muscle over activity.

Hydrotherapy may help decrease spasm severity, promote functional independence, improve motor recovery and decrease medication required for spasticity, which may help reduce the side effects that are possible with oral drug treatments.

Recent studies have reported that electrical stimulation of acupoint (ESA; electroacupuncture) is effective in treatment of stroke patients with spastic hypertonia[4] . Stimulation of the peroneal nerve[5] or acupuncture points of the affected leg[6] via transcutaneous electrical nerve stimulation (TENS) can reduces plantarflexors spasticity, improves dorsiflexor strength, improve gait, and motor function in spastic hemiparetic patients. Bobath inhibitory technique is one of the approaches used to reduce the activity of stretching reflex and spasticity[7, 8].

The main purpose of this study is to investigate whether TENS combined with Bobath inhibitory technique was more effective than Bobath given alone in reducing spasticity of stroke patients.

METHODS

A randomized controlled trial was conducted at the Rehabilitation department of Tongji medical hospital over a period of 18 months from February 2009 to October 2010.

After approval from hospital ethical committee, a total of 30 patients suffering from stroke, in their spastic phase of rehabilitation were recruited. Physical examination in parallel with diagnostic findings of CT-Scan and MRI of the brain were used to make confirmation of the disease. Stroke patients with either clinically proven hemiplegia or hemi paresis, muscle spasm degree as defined by modified Ashworth scale 1, 3-6 months of disease or only able to walk>10m either with supervision or with some aid were recruited in the study. Patients with chronic debilitating diseases or concomitant disorders like angina pectoris, myocardial infarction, and severe aortic stenosis or with artificial pacemakers were excluded from the study. Similarly, patients who have underwent TENS therapy ever in

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the past or fixation of ankle joint or foot contracture were not included in the study. The participants were then randomly divided in to two groups based on therapeutic measures. The combination study group included fifteen subjects who underwent combined Bobath and TENS therapy. The control group involved rest of the fifteen patients who received the Bobath treatment only. (Figure 1)

TENS application included 30 minutes of TENS, delivered through two pairs of self-adhesive electrodes attached to the following acupuncture points on the affected lower extremity: ST 36 (tibialis anterior muscle, lateral to the tibia at the level of the tuberositas tibiae), LV 3(on the depression distal to junction of the first and second metatarsal bones), GB 34 (in the depression anterior and inferior to the head of the fibula) and UB 60 (In a depression between the tip of the external malleolus and the achilles tendon.), with the cathodes placed proximally. These acupoints were selected according to traditional Chinese medicine[9] and previous stroke studies[10,11.] To increase the conductivity of the electrodes and to relieve the burning sensation of the patients, a non-allergic water-based gel was used on the side of the electrodes contacting with the skin. The characteristic of the current was (100 Hz frequency, pulse width 0.2 ms 2 to 3 time's sensory threshold)

Bobath inhibitory techniques included 15 minutes passive movement of the big toe and the other four toes extension, ankle joint dorsiflexion, knee joint extension, abduction and external rotation of hip joint, which is known as the reflex inhibitory pattern[12].

Treatment in the two groups was continued for 4 weeks, 5 days a week as one session per day for a total of 20 sessions.

The participants of the study underwent comprehensive and detailed clinical evaluation both before the start as well as end of the therapy and were assessed by the same investigator. The modified Ashworth scale[13,14] was used to measure Planter flexors spasticity. To facilitate data analysis, a 6-point rating scale range from 0 (no increase in muscle tone) to 4 (affected part rigid in flexion or extension) was used. To increase reliability, only one experienced physical therapist performed a blinded measurement of muscle tonus (MAS) during all test trials.

A hand-hold goniometer was used to measure passive ankle joint dorsiflexion range of motion. The axis of the goniometer was placed 2 cm below the medial malleolus of the ankle joint, while its fixed arm was placed along the long axis of leg and its moving arm placed along the long axis of first metatarsal bone. The reference position was the right angle between foot and leg. The foot was then moved passively to the end of ankle joint dorsiflexion until any resistance was felt. Total free range of motion was measured by placing the moving arm to the new position of the first metatarsal. The average of three measurements was calculated and considered to be the dorsiflexion range of motion.

Strength of the ankle dorsiflexor muscles was measured by Manual muscle strength testing[15] using a numerical scale from o (no contraction at all) to 5 (normal contraction).

Motor function of the lower limb was measured with Brunnstrom stage[16]. The 6 grades of the Brunnstrom stages for the lower extremity are as follows: (1) flaccidity, (2) synergy development (minimal voluntary movements), (3) voluntary synergistic movement (combined hip flexion, knee flexion, and ankle dorsiflexion, both sitting and standing), (4) some movements deviating from synergy (knee flexion exceeding 90° and ankle dorsiflexion with the heel on the floor in the sitting position), (5) independence from basic synergies (isolated knee flexion with the hip extended and isolated ankle dorsiflexion with the knee extended in the standing position), and (6) isolated joint movements (hip abduction in the standing position and knee rotation with inversion and eversion of the ankle in the sitting position).

Walking speed is one of the most widely accepted measures of lower-limb recovery[17]. 10-Meter Walk Test has been used for gait assessment in stroke. For this test, participants must ambulate 10 meters while being timed so that their walking speed may be calculated. It requires a 14 m straight path, with 2 m for acceleration, 10 m for steady-state walking, and 2 m for deceleration. Markers are placed at the 2 and

12 m positions along the path. The patient begins to walk "at a comfortable pace" at one end of the path, and continues walking until he or she reaches the other end. The Physical Therapist uses a stopwatch to determine how much time it takes for the patient to traverse the 10 m center of the path, starting the stopwatch as soon as the patient's limb crosses the first marker and stopping the stopwatch as soon as the patient's limb crosses the second marker

All the statistical analyses were performed buy using SPSS version 15,Copyright SPSS,Inc.,Chicago, Illinois 60606, USA , StatXact 6, CYTEL Software Corp., Cambridge, MA 02139, USA and SAS (Statistical Analysis System) version 8.2 .Standard descriptive statistics were used to characterize sample mean and standard deviation. Student's t-test was used to test for possible significant differences in ordinal and continuous variables. Range was calculated for continuous variables and frequencies and percent for categorical variables. The chi-square test was carried out to compare proportions. A p-value <0.05 was considered statistically significant.

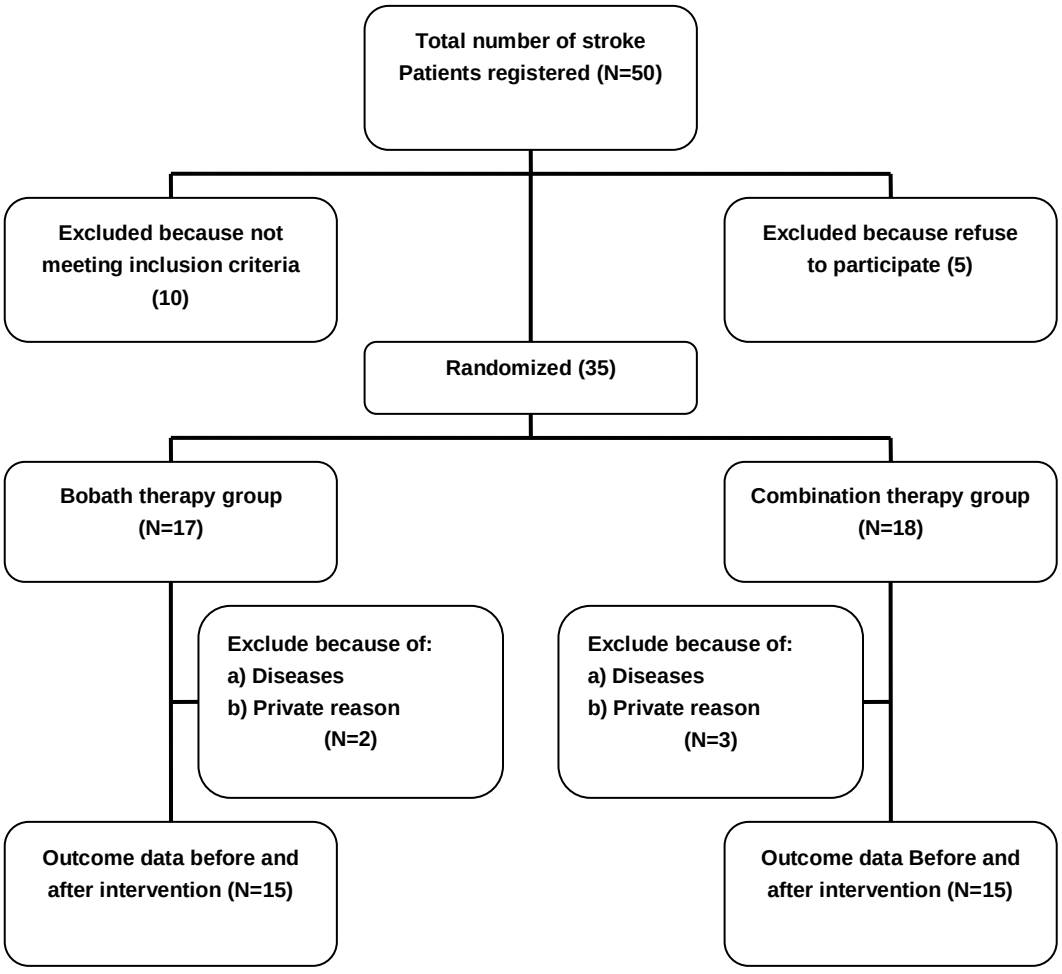

Figure 1 Flow diagram of study

RESULTS

The mean age of the patients was 55.2 years (range 37 to 70 years) and mean duration of stroke was 4.73 months (range 3 to 8 months). There were no significant differences in ages, sex, severity of spasticity, and time from stroke at baseline among groups. The characteristics of the subjects are shown in Table 1.

Table 1. Characteristics of Subjects

	Bobath group	Combination group
Age (y)	57.6 ± 6.53	53.6 ± 7.35
Gender (F/M)	5/10	7/8
Duration of Stroke(Months, Mean ± SD)	4.45 ± 1.05	5.01 ± 1.28
Stroke Type(Hemorrhage/ Ischemia)	10/ 5	12/3
Side of Rigidity(R/L)	8/7	10/5
Height (cm)	165 ± 4.21	163 ± 3.89
Weight (kg)	64.8 ± 5.83	65.5 ± 7.22

The results of our study clearly indicated that the parameters selected for experimentation were definitely improved and much better among the group, to whom the combined therapy of TENS with Bobath was given i.e.; Group 1.

The mean±SD values of ankle passive dorsiflexion ROM, MAS, Lower extremity BS, Ankle dorsiflexor strength and 10 meters walk test are summarized in table II for the participants of the study, both before and after the therapy phase in two predefined groups.

It is clearly evident from the results that ankle passive dorsiflexion ROM is statistically significant only after the therapy phase (22.60±2.87G1, 21.60±4.07 G2, $p<0.05$ Vs 15.33±4.05 G1, 17.67±4.56 G2, $p>0.05$ NS), but its significance remains the same among the two groups after treatment whatever the kind may be i.e., the combination therapy and solely Bobath group. The mean value also proved to be significant showing that whatever the mode of therapy is; the treatment is useful among all kinds of post stroke patients. The other parameters showed a slight interesting pattern.

All the rest measurements showed that they came out to be clinically significant among both the groups of the patients after treatment, but their significance was more among group 1 of combined therapy with TENS and Bobath both in comparison to just Bobath therapy group.

The mean group value showing maximal significance was 10 meters walk test (mean change 0.06±0.04 G1, 0.02±0.01 G2, $p=0.001$).This shows that the combined effect of TENS –Bobath therapy has extremely beneficial role in making the 10 meters walk test of the patient better followed by muscle tonus as measured by MAS(mean change -1.27±0.80 G1, -0.53±0.64 G2,$p=0.001$).The remaining parameters also remained significant in all the participants after therapy regardless of the group, but parameters were statistically more significant in combination therapy group 1 than Bobath group 2.

It shows that this combined TENS-Bobath treatment was also much useful in improving the lower extremity BS and ankle dorsiflexor strength of the muscles among the subjects.

Table II. Comparison of pre-treatment and post-treatment values of clinical parameters.

	Before Before treatment			After After treatment		Mean change Mean change		
Parameters	G1 mean ±SD	G2 mean ±SD	P	G1 mean ±SD	G2 mean ±SD	Group 1	Group 2	p
Ankle passive dorsiflexion ROM	15.33 ±4.05	17.67 ±4.56	0.149	22.60 ±2.87 0.0001	21.60 ±4.07 0.0001	7.27±1.67	3.93±1.16	0.0001
MAS	3.27± 1.10	3.00± 1.07	0.506	2.00± 0.76 0.0001	2.47± 0.99 0.006	-1.27±0.80	-0.53±0.64	0.009
Lower extremity BS	2.73± 0.96	3.07± 0.88	0.331	3.53± 0.92 0.001	3.27± 0.80 0.04	0.80±0.77	0.20±0.41	0.0132
Ankle dorsiflexors strength	0.80± 0.86	1.00± 0.93	0.5452	1.73± 0.80 0.0001	1.47± 0.99 0.0135	0.93±0.46	0.47±0.64	0.02
10 test	0.40± 0.16	0.45± 0.17	0.4288	0.46± 0.16 0.0001	0.476 ±0.17 0.0003	0.06±0.04	0.02 ±0.01	0.001

G1: Combination of TENS-Bobath Group, G2: Bobath Only Group

DISCUSSION

Nearly all studies on the recovery of motor function in stroke survivors have found that the most rapid recovery occurs during the first few weeks after stroke. In a meta-analysis of 36 clinical trials in stroke rehabilitation. Ottenbacher and Jannell noted that early initiation of rehabilitation for stroke patients was related to improved motor and functional outcomes[18]. Kwakkel et al critically reviewed 9 controlled studies involving 1051 stroke survivors who received rehabilitation programs of different intensities. They found a small but statistically significant intensity effect relationship[19]. These results suggested that early and intensive intervention could significantly improve motor recovery and functional outcome in stroke survivors.

In the Western world, the Bobath Concept or neurodevelopmental treatment is the most popular treatment approach used in stroke rehabilitation, yet the superiority of the Bobath Concept as the optimal type of treatment has not been established. Therapy based on the Bobath Concept aims to regain motor control and function of the hemiparetic side after stroke without promoting compensation. Facilitation of normal movement components (which includes strategies to maintain muscle and joint alignment) and task-specific practice using specific manual guidance have been identified as critical elements of the Bobath Concept[20].
A more recent publication by Raine states that the aim of therapy is to optimize postural and movement strategies to improve efficiency so that patients can achieve their maximum potential; the aim is not about achieving

normal movement. Because the content of the Bobath Concept has changed over time, assumptions have been adapted and the content of each particular study's therapy is usually undefined, rarely described, and most likely variable; it is difficult to know what precisely constitutes this concept[21]. However, what is known is that a number of original assumptions of the Bobath Concept show intrinsic weaknesses. Only some of these assumptions about recovery of motor control and function have been put to the test in research. Bobath therapists have assumed that a symmetrical weight distribution implies better postural control, but this perceived relationship between symmetry in weight distribution while standing and walking and balance has not been proven. For example, Kirker et al found that standing patients with stroke are more stable when they keep their postural control over the unaffected limb.

This finding suggests that the asymmetrical stance in hemiparesis may be necessary to compensate for muscle weakness, delayed muscle activation, synergistic-dependent activation patterns of muscles, and perceptual deficits. In other words, asymmetry does not necessarily imply decreased postural control and higher risks of falls.

CONCLUSION

Our study clearly reflected that using the TENS along with Bobath is extremely beneficial for the subjects suffering from stroke, upper motor neuron lesion and are in the rehabilitation phase of therapy. The functional performance of the participants can be achieved at much earlier stage with combined therapy rather than a single group of Bobath. The role of combined therapy must be implicated in health care facilities, so as to facilitate the rehabilitation phase of stroke, reducing the disability.

Since, this study was conducted over 30 subjects, so there are also some limitations attached with this study but still efforts were maximized to make standardization among the groups of patients up to maximal strength. Since previous studies have also shown beneficial role of combined therapy in comparison to single, so there is a need to apply this knowledge regarding the benefit of this combined therapy and it should be implemented in all the rehabilitation clinics.

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CONFLICT OF INTERESTS

There are no conflicts of interests and there is nothing to declare.

REFERENCES

1. Klimkiewicz P, Kubsik A, Woldańska-Okońska M. NDT-Bobath method used in the rehabilitation of patients with a history of ischemic stroke, Wiad Lek. 2012;65(2):102-7.
2. Mikołajewska E. NDT-Bobath method in normalization of muscle tone in post-stroke patients. Adv Clin Exp Med. 2012 Jul-Aug;21(4):513-7.
3. Czupryna K, Nowotny J. Changes of kinematics parameters of pelvis during walking under the influence of means facilitates treatment of cerebral palsied children. Ortop Traumatol Rehabil. 2012 Sep-Oct;14(5):453-65
4. Czupryna K, Nowotny J. Changes of kinematics parameters of pelvis during walking under the influence of means facilitates treatment of cerebral palsied children. Ortop Traumatol Rehabil. 2012 Jul-Aug;14(4):371-83.
5. Yue ZH, Li L, Chang XR, Jiang JM, Chen LL, Zhu XS. Comparative study on effects between electroacupuncture and acupuncture for spastic paralysis after stroke, Zhongguo Zhen Jiu. 2012 Jul;32(7):582-6.
6. Huseyinsinoglu BE, Ozdincler AR, Krespi Y. Bobath Concept versus constraint-induced movement therapy to improve arm functional recovery in stroke patients: a randomized controlled trial. Clin Rehabil. 2012 Aug;26(8):705-15.

7. Kim MW, Chung YC, Jung HC, Park MS, Han YM, Chung YA, Maeng LS, Park SI, Lim J, Im WS, Chung JY, Kim M, Mook I, Kim M. Electroacupuncture enhances motor recovery performance with brain-derived neurotrophic factor expression in rats with cerebral infarction. Acupunct Med. 2012 Sep;30(3):222-6.
8. Akhavan Hejazi SM, Mazlan M. Concurrent peripheral pathologies and complex regional pain syndrome type 1 as contributors to acute post-stroke shoulder pain: a case report. Acta Med Iran. 2012;50(4):292-4.
9. Cheng JS, Yang YR, Cheng SJ, Lin PY, Wang RY. Effects of combining electric stimulation with active ankle dorsiflexion while standing on a rocker board: a pilot study for subjects with spastic foot after stroke. Arch Phys Med Rehabil. 2010 Apr;91(4):505-12.
10. Kesar TM, Perumal R, Jancosko A, Reisman DS, Rudolph KS, Higginson JS, Binder-Macleod SA. Novel patterns of functional electrical stimulation have an immediate effect on dorsiflexor muscle function during gait for people poststroke. Phys Ther. 2010 Jan;90(1):55-66.
11. Lee SY, Im SH, Kim BR, Choi JH, Lee SJ, Han EY. The effects of neuromuscular electrical stimulation on cardiopulmonary function in healthy adults. Ann Rehabil Med. 2012 Dec;36(6):849-56.
12. Vivodtzev I, Decorte N, Wuyam B, Gonnet N, Durieu I, Levy P, Cracowski JL, Cracowski C. Benefits of neuromuscular electrical stimulation prior to endurance training in patients with cystic fibrosis and severe pulmonary dysfunction. Chest. 2012 Aug 13.
13. Chu JM, Bao YH, Zou C, Zhao HL, Gong Y, Wang CM. Randomized controlled clinical trials for electroacupuncture treatment of urinary incontinence in stroke patients, Zhen Ci Yan Jiu. 2011 Dec;36(6):428-32.
14. Huang Z, Huang F, Yan HX, Min Y, Gao Y, Tan BD, Qu F. Dysphagia after stroke treated with acupuncture or electric stimulation: a randomized controlled trial, Zhongguo Zhen Jiu. 2010 Dec;30(12):969-73.
15. Wang XB, Chen J, Li TJ, Tao J, Chen LD, He J, Chen LR. Effect of electroacupuncture in different frequencies on electromyography and ambulation in stroke patients with lower-extremity spasticity: a randomized controlled study, Zhongguo Zhen Jiu. 2011 Jul;31(7):580-4.
16. Li N, Tian FW, Wang CW, Yu PM, Zhou X, Wen Q, Qiao XL, Huang L. Double-center randomized controlled trial on post-stroke shoulder pain treated by electroacupuncture combined with Tuina, Zhongguo Zhen Jiu. 2012 Feb;32(2):101-5.
17. Sabut SK, Sikdar C, Kumar R, Mahadevappa M. Functional electrical stimulation of dorsiflexor muscle: effects on dorsiflexor strength, plantarflexor spasticity, and motor recovery in stroke patients. NeuroRehabilitation. 2011;29(4):393-400.
18. Foley N, Murie-Fernandez M, Speechley M, Salter K, Sequeira K, Teasell R. Does the treatment of spastic equinovarus deformity following stroke with botulinum toxin increase gait velocity? A systematic review and meta-analysis. Eur J Neurol. 2010 Dec;17(12):1419-27.
19. Ansari NN, Naghdi S. The effect of Bobath approach on the excitability of the spinal alpha motor neurones in stroke patients with muscle spasticity. Electromyogr Clin Neurophysiol 2007; 47: 29–36.
20. Tiebin Yan, MD, Christina W. Y. Hui-Chan, transcutaneous electrical nerve stimulation on acupuncture points improves muscle function in subjects after acute stroke : A randomized controlled trial. J Rehabil Med 2009; 41: 312–316.
21. Wong AMK, Su TY, Tang FT, Cheng PT, Liaw MY. Clinical trials of electrical acupuncture on hemiplegic stroke patients. Am J Phys Med Rehabil 1999; 78: 117–22.

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