Efficacy of Multiple Proprioceptive and Exteroceptive Stimuli of Foot on Correction of Gait Abnormalities of Stroke Patients

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ABSTRACT

Gait abnormalities are common problems of stroke patients. The main aim of this study was to investigate the effect of specific physical therapy reeducation program consisting of multiple proprioceptive and exteroceptive stimuli of foot muscles on gait of stroke patients. Twenty stroke patients participated in this study (15 males and five females). Their ages ranged between 48 – 62 years with a mean value of 55.1 ± 5.04. All patients received a reeducation program for evertor muscles of the affected foot consisting of quick stretch, tapping, synkinetic movements, electromyographic biofeedback (EMGB) training and graduated active exercises for successive six weeks (three times weekly). Assessment of walking speed, single limb support and gait cycle time through using Qualysis Motion Analysis System (QMAS) were performed for all patients at the start and at the end of treatment. Results of the study showed significant decrease in gait cycle time and significant increase of both walking speed and single limb support. It can be suggested that a specific reeducation program of the evertor muscles can improve many gait abnormalities of stroke patients.
Key words: *Stroke-Electromyographic biofeedback-Opto-Electronic-Gait Analysis.*

INTRODUCTION

Gait abnormalities are common problems of stroke patients. The ability to walk carefully and independently is an important functional goal for stroke patients. A normal gait pattern requires in addition to trunk control both proximal control (of the pelvis and hip) and distal control of foot movements. Distal movements are usually severely impaired more than proximal one due to the nature of pyramidal tract lesion (Dickstein & Abulaffio, 2000). Improper foot function affects the muscular activities in the entire lower extremity. This improper foot function results from under activity of ankle dorsiflexors and subtalar evertors and over activity of ankle planter flexors and invertors. This in turn leads to foot abnormalities specially equino-varus deformity which constitute a serious problem for recovery of normal gait in stroke patients (Voigt and Sinkjaer, 2000). The lack of descending excitatory impulses and firing to the peroneal muscles is thought to be main factor causing this problems (Adam and Perry, 1994).

Different methods are suggested to overcome this problem but non of them solved this problem. This study suggested a multi-system sensory inputs through quick stretch, tapping, synkinitic movements and biofeedback in which spatial summation of these inputs can collectively reduce the muscular imbalance between evertors and invertors and compensate the missed eversion component of foot muscles during gait.

SUBJECT, MATERIALS AND METHODS

Subjects

Twenty stroke patients of both sexes (15 males and five females) participated in this study. Their ages ranges from 48-61 year with mean age of 55.1 ± 5.04. Nine of them were left sided and eleven were right sided hemiplegic. Duration of illness ranges from six months post stroke up to 18 months with mean duration of illness of 8.94 months. Seven of them were hemorrhagic and thirteen ischemic lesions. Type and localization of the lesion was verified by C.T. or MRI scanning of patients. All patients have the ability to stand and walk independently but with certain degree of various deformity of foot.

Materials

- Opto-electronic motion analysis (Qualisys motion capture system) was used in this study to measure the various abnormal position of the affected foot during gait, as well as, to measure walking speed, single limb support and the time of gait cycle.
- Pro-Reflex MCU 120 (motion capture unit): composed of a camera system with six cameras (units) to perform multi camera measurements.
- A wand-kit used for the calibration of the system, serial interface adapter and PC computer with Q trac and Q gait software.

Procedure

Six weeks reeducation program of foot evertor muscles three times weekly, one hour each session were applied consisting of quick stretch, tapping on foot evertors, synkinetic movements to reinforce evertors of the foot from supine and side lying positions, biofeedback training and graduated active exercises.

Measurements of the degree of varus deformity, muscle strength of foot evertors and gait parameters, including walking speed, single limb support and gait cycle time were assessed before treatment and after six weeks of application of the program.

RESULTS

The results of this study is represented in the following tables and figures.

Table (1): Pre and post treatment mean values of degree of varus deformity during gait (degree).

	Pre	Post	t	P
Mean	12.08	8.26	4.23	0.0001
SD	2.63	**2.90**		

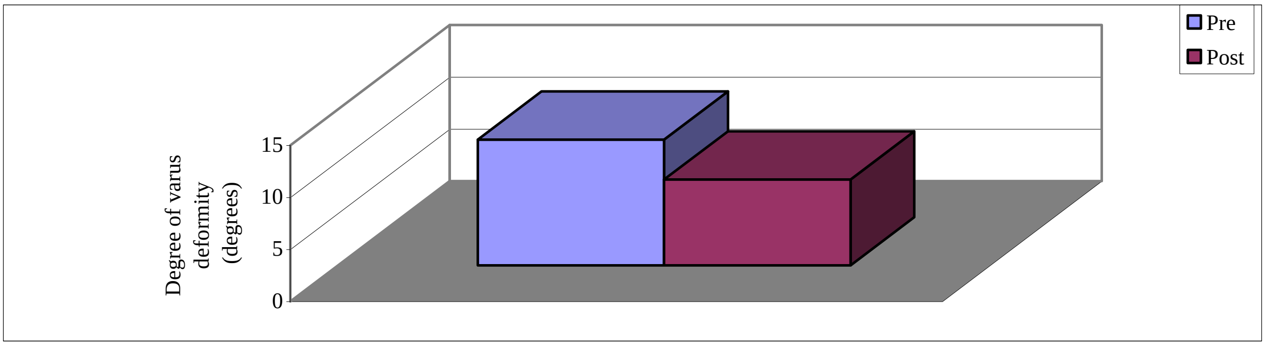

Fig. (1): Changes in the mean values of the degree of varus deformity (degrees) during gait at pre and post treatment.

Table (2): Pre and post treatment mean values of evertors muscle strength.

	Pre	**Post**	**t**	**P**
Mean	2.15	3.14	-4.65	0.0001
SD	0.67	0.68		

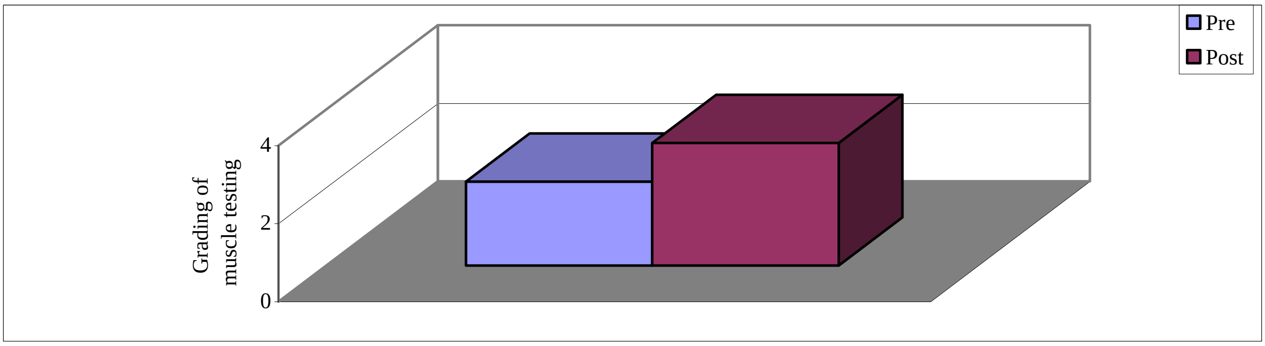

Fig. (2): Changes in the mean values of the degree of foot evertors muscle strength during gait at pre and post treatment.

Table (3): Pre and post treatment mean values of walking speed (m/sec.).

	Pre	**Post**	**t**	**P**
Mean	0.37	0.52	3.27	0.002
SD	0.14	0.13		

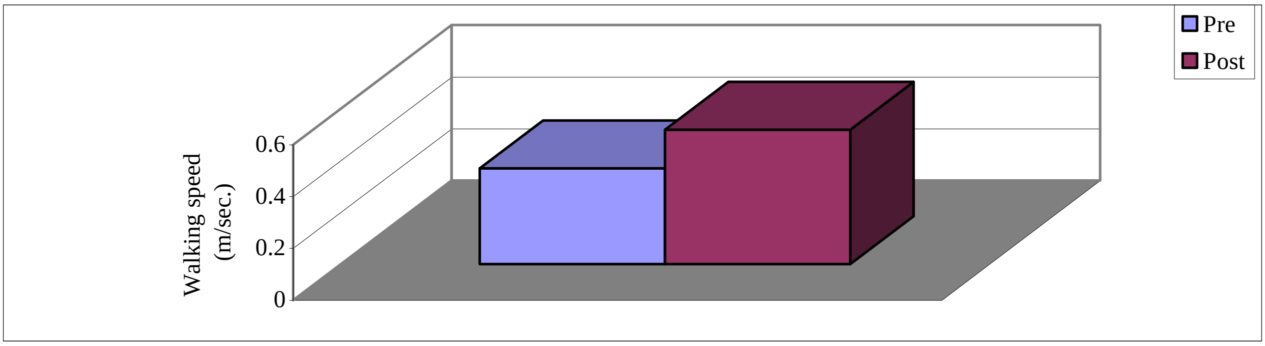

Fig. (3): Changes in the mean values of walking speed (m/sec.) during gait at pre and post treatment.

Table (4): Pre and post treatment mean values of single limb support during gait cycle (% of gait cycle).

	Pre	Post	t	P
Mean	20	27.4	-4.95	0.0001
SD	5	4.42		

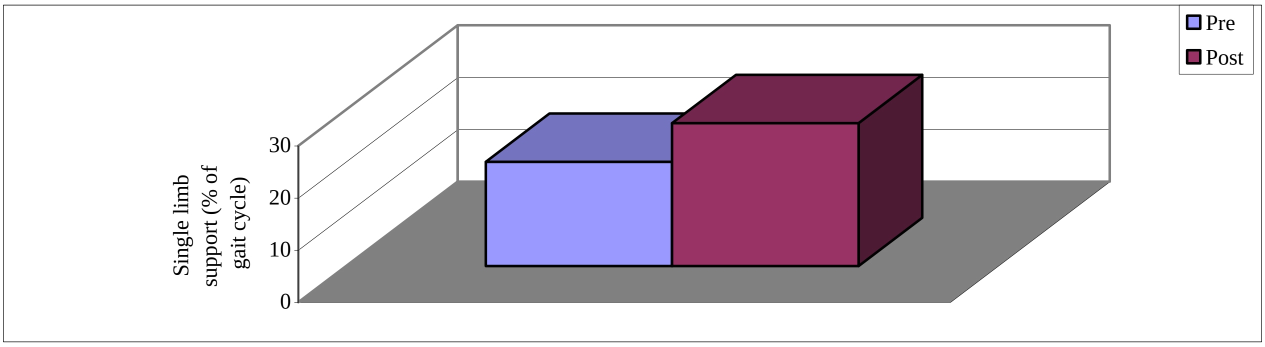

Fig. (4): Changes in the mean values of single limb support (% of gait cycle) during gait at pre and post treatment.

Table (5): Pre and post treatment mean values of gait cycle time (sec.).

	Pre	Post	t	P
Mean	1.81	1.48	3.11	0.004
SD	0.36	0.3		

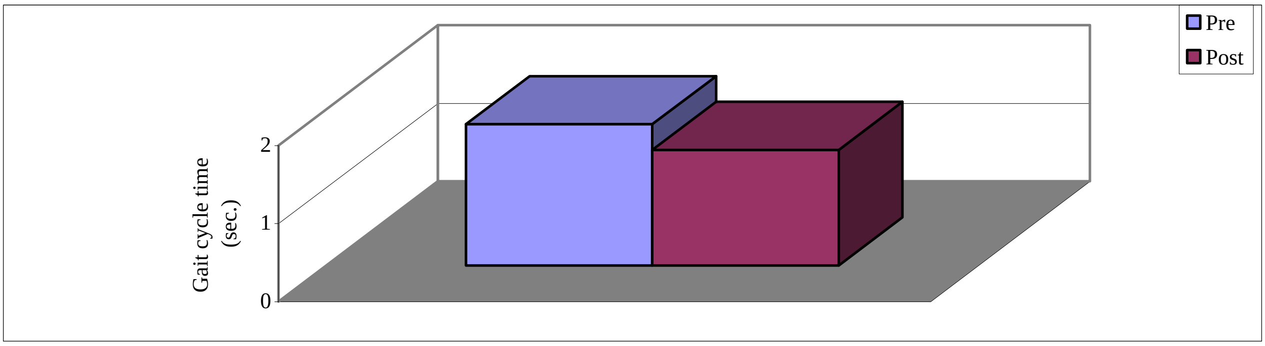

Fig. (5): Changes in the mean values of gait cycle time (sec.)during gait at pre and post treatment.

DISCUSSION

In this study, there was a significant decrease in the degree of varus deformity at the end of the re-education program. This suggests that the application of such program was effective in improving the degree of varus deformity in stroke patients. This can be explained as follows:

The occurrence of varus deformity following stroke can be attributed to two main causes: 1) lack of firing of the peroneal muscles which is due to loss of the descending excitatory impulses (i.e, weakness in the peroneal muscles) (Adams & Perry, 1994), and 2) over activity of tibialis anterior with premature activation of the planter flexors (which are considered to be the antagonists of the peroneal muscles) (Iwaya, 1984; Adams & Perry, 1994).

In the present study, it can be suggested that, this re-education program can produce excitation of the parietal lobe (through stimulation of proprioceptors, exteroceptors, visual and auditory inputs). This in turn excites the motor cortex. The excitation of the motor cortex might facilitate the proper motor neurons, and the appropriate number of motor neurons that are required for this activity. In turn, this excitation is accompanied by inhibition of the inappropriate motor neurons. The excitation of the motor cortex will increase the descending excitatory impulses to the peroneal muscles (more firing), and therefore improving their strength.

Moreover, it can be thought that this increase in motor neuron firing of the peroneal muscles is one of the causes that may modulate the abnormal activities of the tibialis anterior and planter flexors through reciprocal innervation i.e, excitation of one group of muscles is often associated with inhibition of the antagonistic group of muscles (Ganong, 1999). As for the strength of foot evertors, there was a significant improvement in muscle strength by the end of the reeducation program. This suggests that the application of such program was effective in improving muscle strength of the weak peroneal muscles following stroke.

The explanation of these findings can be postulated to the use of facilitatory techniques like quick stretch, tapping, that can facilitate muscle contraction through their action primarily on the muscle spindle primary endings (Ia). It has been accepted that prestretching the muscle by starting contraction in the lengthened range optimize tension development through increased use of viscoelastic forces. For this reason, it can be suggested that, the use of quick stretch and tapping can potentiate each other and produce reflex contraction of the peroneal muscles while providing weak inhibition of the antagonistic muscles through reciprocal innervation. This agrees with the opinion of O'sullivan (1994) and Ganong (1999).

This effect was re-inforced by the application of synkinetic movement in which resistance was applied to hip abductors while instructing the patient to evert his foot. The use of synkinetic movement causes more firing and recruitment in the foot evertors. This is in agreement with the opinion of Sawner & LaVigne (1992). EMG biofeedback add more reinforcement for evertors muscles, this can be justified by many reasons:

1) Following stroke, poor motor control was found to be due to poverty of motor unit recruitment in the prime mover and this lead to muscle weakness. It is thought that EMG biofeedback was effective to overcome this problem by increasing motor unit recruitment of the weak muscles. It

was achieved through teaching the patient to increase the electrical activity of the weak muscle and rebuilding more voluntary control over them. This increase in the electrical activity of the muscle causes increase in strength of this muscle. this opinion is consistent with that of Middaugh & Miller (1980), Mulder & Hulstijn (1984), Mulder et al. (1986), Herrington (1996) and Basmajian (1998).

2) Repeated passage of excitation over the same neural pathways makes it progressively easier for subsequent transmission through decreasing the synaptic impedance along this neural pathway. So, it can be suggested that EMG biofeedback can provide facilitation of the trained muscles. This effect is most probably due to its ability to help the patient to repetitively contract the target muscles. This is supported by Gardner (1970) and Mulder & Hulstijn (1984).
3) The repetitive contraction of the peroneal muscles (by the help of EMG biofeedback) might produce some local effects within the muscles themselves such as: a) a temporary increase muscle metabolism with its associated consequences of increased oxygen uptake and carbon dioxide, lactic acid and other metabolite production, b) raised local temperature, greater local blood flow and an increase in blood supply followed by an increase in capillary density surrounding the trained muscle fibers. All of these local effects can contribute to the improvement in muscle strength. This assumption agrees with the findings of Takebe et al. (1975) and Low & Reed (2000).
4) EMG biofeedback with its audio-visual inputs can provide good information on the outcome of the subject's effort to contract the muscle. Also, it can improve the sensory awareness of the trained muscle through the repetitive movement training and this agree with the findings of Basmajian (1981). This improvement in the sensory awareness of the trained muscles can be considered one of the factors that may help in improving muscle response and facilitation.

The repetitive motor training via EMG biofeedback with its potent facilitatory effect added to it the cumulative effect from quick stretch, tapping and synkinetic movement, all of these cause a significant improvement in muscle strength of the peroneal muscles (peroneus longus and brevis).

In this study, there was a significant improvement in strength of foot evertors at the end of the re-education program. This improvement in muscle strength was reflected on ROM of subtalar eversion giving significant improvement at the end of the treatment period similar to muscle strength. This in turn causes decrease in the degree of varus deformity at the end of the treatment. These results can be explained; the application of this re-education program for the peroneal muscles was effective in decreasing the degree of varus deformity as a secondary consequence of improving the strength of the peroneal muscles and in turn improving the ROM of subtalar eversion. This is because when the joint mobility become limited, and the muscles around it become weak, this in turn will enhance the development of the joint deformity.

The significant improvement of evertors muscle strength and the significant decrease in the degree of varus deformity during gait were effective in ensuring better foot placement on the ground during gait and hence better weight distribution on both feet and better postural balance. These in turn lead to a significant decrease in gait cycle time and a significant increase in single limb support on the affected side. The significant decrease in gait cycle time and the significant increase in single limb support on the affected side, result in significant improvement in walking speed. This opinion agrees with the findings of Cozean et al. (1988).

Therefore, the cumulative effect of quick stretch, tapping, synkinetic movement, EMG biofeedback and graduated active exercises on foot evertors were the main justification of the significant improvement at the end of this re-education program. So, it can be suggested that with a proper re-education program for the peroneal muscles following stroke, foot inversion deformity can be improved.

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الملخص العربي

فاعلية تنبيه المستقبلات العميقة والسطحية بالقدم على تصحيح المشي بمرضى الساكتة الدماغية

يعتبر اعتلال المشي من المشكلات الأكثر شيوعا" التي تواجه مرضى السكتة الدماغية. أجريت هذه الدراسة بهدف معرفة تأثير برنامج علاجى معين لإعادة تأهيل عضلات القدم القالبة للخارج فى مرضى السكتة الدماغية وذلك أثناء المشي . ويتكون هذا البرنامج من العديد من المنبهات للمستقبلات الحسية العميقة والمستقبلات الحسية السطحية لعضلات القدم. و قد أجريت هذه الدراسة على عشرين مريضا" من مرضى السكتة الدماغية (خمسة عشرة من الذكور وخمسة من الإناث) الذين تتراوح أعمارهم من 48 إلى 62 عاما" ومتوسط أعمارهم 55,1 ± 5,04 سنة . ويشتمل هذا البرنامج العلاجي على شد العضلات السريع مصحوباً بالنقر مع الحركة المشاركة و التغذية الرجعية باستخدام رسام العضلات الكهربائي بالإضافة إلى الحركة الحرة المتدرجة لعضلات القدم المصابة القالبة للخارج . وتم تطبيق هذا البرنامج لمدة ستة أسابيع متتالية بمعدل ثلاث مرات أسبوعيا مع تقييم نتائج البحث عند بداية وعند نهاية العلاج . وقد تم ذلك بقياس بعض معايير المشى مثل سرعة المشي و النسبة المئوية للثبات على القدم المصابة أثناء المشي وزمن دورة المشي باستخدام جهاز تحليل الحركة ثلاثي الأبعاد . ولقد أسفرت المعالجة الاحصائيه للنتائج عن وجود انخفاض ملحوظ ذو دلالة إحصائية فى زمن دورة المشى بالإضافة إلى وجود زيادة ملحوظة ذو دلالة إحصائية فى سرعة المشي و النسبة المئوية للثبات على القدم المصابة. وبناءا" على هذه ال نتائج فإن تطبيق برنامج علاجى معين لإعادة تأهيل عضلات القدم القالبة للخارج من الممكن ان يحسن الكثير من مشاكل المشي فى مرضى السكتة الدماغية .