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Original Research Article

TRANSCRANIAL MAGNETIC STIMULATION VERSUS ELECTRICAL VESTIBULAR STIMULATION ON BALANCE IN GERIATRICS PARKINSONIAN PATIENTS

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ABSTRACT

Background: The aim of this work was to investigate the efficacy of transcranial magnetic stimulation versus electrical galvanic vestibular stimulation on balance in geriatrics parkinsonian patients.

Subjects and Methods: sixty geriatrics Parkinsonism male patients represent the sample of this study. The patients' ages ranged from 60 to 70 years with a mean value of 65.983 ± 2.76 years. They were assigned randomly into three equal groups; the study group one (G1) and the study group two (G2) and the control group (G3). The control group G3 treated by selected therapeutic physical exercise program. The study group G1 treated by the same program of treatment as the control group in addition to Transcranial magnetic stimulation TMS. The study group (G2) treated by the same program of treatment as G3 in addition to galvanic vestibular stimulation (GVS). The duration of treatment was three months, three times per week. The different aspects of dynamic balance (overall stability, anteroposterior stability and mediolateral stability indices) were assessed pre and post treatment objectively by Biodex balance system and clinically by Short Form of Berg Balance Scale (SFBBS) in all groups.

Results: Comparison of each variable pre and post treatment in each group revealed a significant improvement in all different parameters in study groups (G1 & G2) $P \leq 0.05$; however the control group showed a significant improvement only in anteroposterior stability index.

Conclusion: Transcranial magnetic stimulation and GVS have significant effect on treatment of balance disorders in geriatrics Parkinsonism patients.

KEY WORDS: Parkinsonism, Transcranial magnetic stimulation, galvanic vestibular stimulation, Balance.

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INTRODUCTION

Parkinson disease (PD) is a neurodegenerative progressive chronic, disorder. At least 1% of people by age 70 are affected. Parkinson disease (PD) is a relatively common disorder of the nervous system that afflicts patients later in life with tremor, slowness of movement, gait instability, and rigidity. The main clinical features of

PD are rigidity, rest tremor, balance impairment, and slowness of movement [1].

Balance impairment is one of the most distressing symptoms in Parkinson disease (PD), people with PD have an increased risk of falling and a fear of falling is usually common. The balance impairment remains a limitation despite the use of anti-PD medication. Postural instability has been reported to be the major cause for falling in PD. Postural instability and falls negatively influence health related quality of life .Balance dysfunction is one of the most common functional deficits encountered by physical therapy clinicians [1, 4].

Electrical stimulation to the brain areas through vestibular system pathway is considered a new non-invasive modality. It provides a direct connection to the brain areas and a central intervention modality [3, 4]. Transcranial magnetic stimulation (TMS) is a noninvasive technique used to assess corticospinal excitability and the plasticity of the central nervous system (CNS). TMS is a series of magnetic pulses that temporarily summate and change neural activities. TMS can modulate the excitability of the motor cortex beyond the period of stimulation. TMS has been used to measure CNS adaptation and its relationship to changes in neural control and function [5].

The rationale for the application of TMS The patients' responses to TMS included a feeling of relaxation, partial or complete disappearance of muscular ache and L-dopa-induced dyskinesias as well as rapid reversal of visuos-patial impairment [6, 7]. Clinical applications of TMS were first reported by Barker and colleagues who stimulated the brain, spinal cord and peri-pheral nerves using TMS with low or no pain. TMS has the potential to alter cortical excitability depending on the duration and mode of stimulation. Small electrical currents are produced by electromagnetic pulse and pass through the skull where they stimulate nerve cells in the targeted brain region. Since this type of pulse generally does not reach further than two inches into the brain, it is possible to selectively target specific brain areas [8, 9].

Effects are primarily directed at surface cortical regions, since the dopaminergic deficiency in PD is localized to the subcortical basal ganglia. However, few reports have examined the relationship between motor cortical excitability of geriatrics parkinsonism patients and the r ecovery of balance ability [10]. The purpose of this study is to determine the effectiveness of TMS versus electrical galvanic vestibular stimulation on balance in geriatrics parkinsonism patients.

PATIENTS AND METHODS

Sixty parkinsonian patients; (All the patients suffered from mild to moderate disability according to UPDRS ADL/motor scores and Modified Hoehn and Yahr staging (Fahn et al., 1987). They were diagnosed and referred by a neurologist. The diagnosis was confirmed by Magnetic Resonance Image (MRI). The patients' age ranged from 60-70 years. Their weight ranged from 81 to 97 kgs, height ranged from 162 to 175 cm. The duration of illness was ranged from one to three years. The assessments and treatment were only done during the "*on*" medication period. The patients were selected from Out-patients' Clinic, Neurology Department, Faculty of Medicine, Cairo University and from Out-patients' Clinic, Faculty of Physical Therapy, Cairo University. The patients were divided randomly into three equal groups:

(1) The Control group (G3) treated by a standard physical therapy protocol with designed program of selected physical exercise. The exercises directed mainly to balance training.

(2) The study group one (G1) treated by Transcranial magnetic stimulation in addition to the same designed program of physical exercise as control group.

(3) The study group two (G2) treated by electrical galvanic vestibular stimulation (GVS) in addition to the same designed program of physical exercise as control group (G3).

The duration of physical treatment was three sessions per week, for three months; duration of galvanic vestibular stimulation at each session was five min. Transcranial magnetic stimulation at each session lasting for about 20 min.

Inclusion criteria for the participation of this study were as follows: Subjects had the following criteria:

(1) All the patients were right handed according to the Edin-burgh Handedness test (Williams and Stephen, 1986) [17] , (2) All the patients were Levodopa dependant, (3) The patients were able to walk independently for six minutes without interruption, and (4) no cognitive impairments (>25 in mini-mental function measure).

Exclusion criteria were as follows: (1) patients with metal within the brain, such as clips for aneurysms, and (2) patients with a cardiac pacemaker, (3) Marked rigidity (more than three according to the rigidity UPDRS subscale), (4) Rapidly progressive motor disability and poor visuospatial abilities. (5) Receiving certain medicines such as sedatives tranquilizers or sleeping aids. All subjects signed an informed consent document prior to participation in the study [5]. For randomization of the three groups; each patient had an envelope with three cards, and they were instructed to blindly draw one of the cards on each occasion.

Assessment Procedure of the patients: All patients were subjected to complete clinical neurological examination (motor, sensory, ADL and gait).

1) Balance index (BI) scores were obtained by means of a balance measurement system (Biodex Balance Master, New York, USA). This system incorporates a specific monitor and a movable force platform, which provides up to 20° of surface tilt in a 360° range of motion, with a visual feedback system. BI refers to the subject's ability to maintain the vertical axis of the body within a suitable range of the balance center of the platform's angle of tilt. A low BI score implies excellent balance ability [13]. The BI has a strong internal consistency, and acceptable intrarater (r=0.82) and interrater (r=0.70) reliabilities [13].

2) Short Form of Berg Balance Scale (SFBBS): It evaluates dynamic balance. It is simple and fast clinical scale commonly used in clinical or a research setting. It includes the following seven items:

- Sitting to standing.
- Standing with eyes closed.
- Reaching forward with outstretched arm.
- Retrieving object from floor.
- Turning to look behind.
- Standing with one foot in front.
- Standing on one foot [4].

Physical therapy program: The patients were assigned randomly into three equal groups.

The patients in control group (G3) treated by the selected physiotherapy program for one hour, this program consisted of:

- Stretching exercises of shortened muscles.
- Facilitation of voluntary motor control and equilibrium and righting reactions.
- Strengthening exercises for abdominal and back muscles.
- Balance training on a balancing board, weight shifting and pushing from different directions.
- Proprioceptive Neuromuscular Facilitation (PNF) techniques for the lower limbs.
- Approximation for both upper and lower limbs.
- Functional training, gait training using external visual and auditory cues.
- Weight shifting from standing position.

The patients in study group one (G1): treated by the designed physiotherapy program in addition to galvanic vestibular stimulation.

- Galvanic vestibular stimulation was set at 1.0 ms, 100 Hz, 5mA bilateral, bipolar galvanic vestibular stimulation to the vestibular system according to Blanke et. al., 2008 [3]. It was applied with two electrodes on right and left mastoid processes for five minutes; three sessions per week.

All the patients were treated by GVS from sitting position on a chair with a back support. The feet rested on the ground with 90º flexed hips and knees. The angle between the feet was about 30 degree, and the minimum distance between the feet was 10 cm. The patients in study group two (G2) treated with Transcranial magnetic therapy as a method of brain stimulation in addition to the same program of selected physical exercises therapy of group three (G3).

ASA Magnetic field for magneto therapy, its model is automatic PMT Quattro pro. Serial number is 00001543. It consists of an appliance, motorized bed and solenoids. The appliance must be connected to electrical mains supply with 220 V± 10% at a frequency of 50 Hz with earth connection. The intensity and spatial

layout of the generated MF depend on the type of the used solenoid whether being for trunk, limb or transcranial. The output wave form is a sinusoidal wave, typical of the magnetotherapy. Frequency of the output impulse ranged from 0.5 to 100 Hz, and its intensity is displayed in percentage form, from 5% to 100% of the maximum layout of the solenoid used; the maximum intensity in Gauss depending on the solenoid used "transcranial solenoid maximum intensity is 80 Gauss" [20]. From sitting position on a chair with comfortable heights and cranial solenoids is positioned where the whole head of the patient is centered inside in the middle area of the transcranial solenoid. The duration of Transcranial magnetic therapy was twenty minutes. Intensity was two gausses. The whole session lasted for about one hour [20].

The BIODEX system was used as a measuring device. It measures the degree of tilting about each axis during dynamic conditions. From the degrees of tilt about the antero-posterior (AP) and mediolateral (ML) axes, the BSS calculates the medial-lateral stability index (MLSI), the anterior- posterior stability in dex (APSI), and the overall stability index (OSI).

These indices are standard deviations assessing fluctuations around the zero point (i.e., horizontal) rather than around the group mean.

The MLSI and the APSI assess the fluctuations from horizontal along the AP and ML axes of the BSS, respectively. In contrast, the OSI is a composite of the MLSI and APSI and, thus, is sensitive to changes in both directions [14].

Statistical Analysis:

Descriptive statistics (mean and standard deviation) were used to assess the baseline characteristics of the study patients [12]. Data were included in a database and analyzed by means of statistical software package namely SPSS Windows V.11. Analytical tests included paired student (t test two sided) for comparing each group. Paired t test was used for comparing values before and after treatment. Level of Significance was P< 0.05. Analysis of variance (ANOVA) was used to assess the difference in general features and in determining the presence of significant difference pre and post testing in all three groups [13].

The mean values of overall stability index for groups (G1), (G2) and control group before starting the treatment are summarized in table (1). Comparison of different aspects of dynamic balance test of (overall stability index, anteroposterior stability index and mediolateral stability index) in all different groups (G1), (G2) and control group (G3) before starting the treatment by using ANOVA (Analysis of variance) showed that there was no significant difference between all groups before treatment. F value for overall stability index for groups (G1), (G2) and control group before starting the treatment was 0.01 at P= 0.985. F value for anteroposterior stability index was 0.00 at P= 0.997. F value for mediolateral stability index was 0.05 at P= 0.945. (Table 1).

Table 1: The mean values of different aspects of dynamic balance tests in all groups (overall stability, anteroposterior stability and mediolateral stability index) before starting the treatment.

Dynamic balance Pre test	Mean ± SD			f- value	P-value
	Study (G1)	Study (G2)	Control (G3)		
Overall stability index	3.190±0.4	3.11±0.4	3.12±0.37	0.23	0.793
A/P stability index	2.61±0.24	2.61±0.21	2.47±0.31	1.9	0.16
M/L stability index	2.05±0.21	1.98±0.24	2.04±0.20	0.53	0.59

SD: standard deviation P ≤ 0.05 = significant*

The different aspects of dynamic balance test results post treatment in all groups (G1, G2 & G3): The mean values of overall stability index post treatment for study (G1), (G2) and control group three (G3) were 1.8±0.42, 2.99±0.44 and 3.05±0.46 respectively. Post treatment the mean values of anteroposterior stability index for different groups; G1, G2 and G3 were 1.38± 0.16, 2.46± 0.21 and 2.40 ± 0.24 respectively. The mean values of mediolateral stability index for different groups; (G1), (G2) and control group three (G3) were 1.02±0.28, 1.91± 0.24, and 1.95±0.38 respectively. Comparison of the mean values of different aspects of dynamic balance test of (overall stability index, anteroposterior stability index and mediolateral stability index) of all different groups (study (G1), (G2) and control group (G3) by using (Analysis of variance) ANOVA post treatment revealed that there was a significant difference between all groups;

at P value = 0.00, Table 2.

Table 2: The post treatment mean values of different aspects of dynamic balance test in all groups (G1, G2 & G3).

Dynamic balance POST test	Mean ± SD			f-value	P-value
	Study (G1)	Study (G2)	Control (G3)		
Overall stability index	1.8±0.42	2.99±0.44	3.05±0.46	46.11	0.00*
A/P stability index	1.38±0.16	2.46±0.21	2.40±0.24	140.97	0.00*
M/L stability index	1.02±0.28	1.91±0.24	1.95±0.38	58.8	0.00*

SD: standard deviation P ≤ 0.05 = significant*

Tables 3, 4 and 5: Comparison between pre and post treatment of the mean values of different aspects of dynamic balance test in all groups (G1, G2 & G3)

Table (3):

stability Overall index	Mean ± SD		
	Study (G1)	Study (G2)	Control (G3)
Pre test	3.19±0.40	3.11±0.40	3.12± 0.37
Post test	1.85±0.42	1.85±0.42	3.05±0.46
t-value	14.72	13.19	0.85
P-value	0.000*	0.000*	0.407

SD: standard deviation P ≤ 0.05 = significant*

Table (4):

A/P stability Index	Mean ± SD		
	Study (G1)	Study (G2)	Control (G3)
Pre test	2.61±0.24	2.61±0.21	2.47±0.31
Post test	1.38±0.16	2.46±0.21	2.29±0.22
t-value	23.72	3.36	3.06
P - Value	0.000*	0.003*	0.006*

SD: standard deviation P ≤ 0.05 = significant*

Table (5):

M/L stability Index	Mean ± SD		
	Study (G1)	Study (G2)	Control (G3)
Pre test	2.05±0.21	1.995±0.22	2.04±0.20
Post test	1.02±0. 28	1.91±0.24	1.950±0.38
t-value	18.31	3.91	1.15
P- Value	0.000*	0.001*	0.266

SD: standard deviation P ≤ 0.05 = significant*

Short Form of Berg Balance Scale (SFBBS) pre and post treatment in all different groups: The mean value for Short Form of Berg Balance Scale (SFBBS) for group one (G1), (G2) and (G3) before starting the treatment summarized in Table 3.

Comparison of the mean values of Short Form of Berg Balance Scale (SFBBS) pre and post treatment in each group indicated a non significant increase in group three (G3) control group as t-value was 1.69 at (P=107). In group one (G1) a significant increase as t-value was 4.7 at (P=0.00). In group two (G2) there was a significant increase in Short Form of Berg Balance Scale (SFBBS) in this group as t-value was 5.82 at P= 0.00 Table 3.

Table 6: The mean values of Short Form of Berg Balance Scale (SFBBS) pre and post treatment in all different groups (G1, G2 & G3).

Short Form of Berg Balance Scale	Mean ± SD			f-value	P- value
	Study (G1)	Study (G2)	Control (G3)		
Pre test	23.35 ± 1.6	23.5±1.7	23.3±1.79	0.07	0.925
Post test	22.5±1.2	23.3±1.4	21.65±1.83	3.51	0.03*
t-value	4.6	5.72	1.59		
P- value	0.00*	0.00*	0.107		

SD: standard deviation P ≤ 0.05 = significant*

DISCUSSION

The main findings of the current study confirmed that repeated Transcranial magnetic stimulation and GVS combined with a program of therapeutic exercises for three months have a positive effect on dynamic balance of geriatrics parkinsonian patients. The study group one, which was treated by TMS in addition to the designed physical therapy program showed greatest improvement in all clinical features and different aspects of dynamic balance. In study group two (G2); GVS in addition to the program of therapeutic exercises for three months showed great improvement in balance and overall functional abilities in dynamic standing abilities.

This study displayed improvement of all tested variables of dynamic balance tests of geriatrics parkinsonian patients. Post treatment a significant reduction of all variables existed in study group one (G1) (treated by TMS). In study group two (G2); a significant reduction was found in all tested variables of dynamic balance test. In the control group (G3) significant reduction was confined to one variable only; (anteroposterior stability index).

In normal subjects, TMS increases cortical excitability beyond the time of stimulation and these changes were thought to correspond to long-term synaptic potentiation (LTP) processes. Optimal recovery after Parkinsonism is thought to occur through the recruitment of pathways that are normally used in healthy subjects.

Thus to ensure a good outcome, it is required that the functional capacity of the affected brain region should be restored [6]. Anninos P. et al.(2007) [19] reported that TMS increases the release of dopamine in the striatum and frontal cortex, which in turn improves PD symptoms including motor performance. They concluded that TMS applied in the prefrontal cortex induces the release of endogenous dopamine in the ipsilateral caudate nucleus as observed by positron emission tomography in healthy human subjects. Cerasa and coworkers, (2015) [18], observed that repetitive TMS applied over the inferior frontal cortex reduced the amount of dyskinesia induced by a supramaximal single dose of levodopa in PD patients, suggesting that this area may play a key role in controlling the development of dyskinesia. The results of these studies show that TMS application results in partial or complete disappearance of muscular pain and L-dopa-induced dyskinesia in addition to an immediate and beneficial effect on corticostriatal interactions that play an important role in the pathophysiology of PD.

The results of the BBS and the SFBBS showed that the TMS group had significantly improved post-intervention values than the GVS group did, which suggests that TMS applied to geriatrics parkinsonian patients was helpful in enhancing the balance function. Balance ability in the primary sensorimotor cortex plays an important role. The cerebrum and cerebellum, which are responsible for the activation of the ability to balance the visual, vestibular, and proprioceptive sensory abilities to affect dynamic balance, seem to be improved. TMS in this study was used to increase brain neuroplasticity, and it was helpful in improving the balance ability of geriatrics parkinsonian patients. The vestibular system provides direct connection to the cerebellum which explains its important role in body balance and spatial orientation. TMS and galvanic vestibular stimulation activates the cerebellum, and an evoked potential was recorded from the cerebellar vermis after stimulation [8, 11].

The Cerebellum contains several pathways and transmits information from the vestibular nuclei that is related to position and movement of head. Cerebellum also consists of different repeating loops through which inputs from other centers are modified and sent out, back to the same structures from which the input are derived. Stimulation to vestibular system improves the cerebellar capacity to compensate the abnormal signals received from the affected cortex. The modified output goes to the cortex again and there improve its function [15, 16].

Improvement of balance and mobility functions in G1 and G2 are attributed to the role of vestibular system in maintenance of spatial orientation gaze and gait stability. This is due to its integrating effect on visual, proprioceptive, and vestibular inputs. This assumption agrees with Hiscock A. et al. (2008) [10].

The current study results come in agreement with *(*David *et al, 2015)* who stated that pathophysiology of balance impairments in PD incorporates multiple subsystems (sensory, motor, and cognition). They expressed imbalance in Parkinson's disease as occurs by combination of many disorders including loss of postural reflexes, insufficiency in postural adjustments, rigidity in the trunk and extremities and akinesia. Introducing balance training program to their PD patients provide great benefits to gait stability [21].

The optimum time for TMS intervention after PD remains unclear, so, we recruited patients 12–18 months after their ictus. Rehabilitation interventions for geriatrics parkinsonian patients with chronic motor deficits are very limited and thus devising new therapeutic options for this group is desirable. It has been suggested that the window of TMS intervention may extend up to years from PD [5], and TMS may thus offer a unique opportunity for those patients with long-standing residual motor deficits after PD. Indeed, we recruited patients up to one and half years after PD and found no correlation between this interval from onset and the magnitude of improvement [8]. Furthermore, the improvement in motor recovery in the current study was seen not only in balance ability but also translated into clinically meaningful improvement in ADL activity and functions, and reduction of disability. A sustained response after the end of treatment is a key issue when considering the clinical application of TMS interventions in geriatrics parkinsonian patients' rehabilitation.

In this study, we found that the improvement obtained in the two real stimulation groups of patients was sustained and was still statistically significant in comparison with the control group for the 12 weeks of follow- up after the start of treatment. This suggests that applying repeated TMS sessions, especially if coupled with adequate physical and balance therapy, can lead to persistent changes in cortical excitability that is translated into clinically relevant functional gains which is sustained beyond the stimulation period and supports the role of TMS in long-term neurorehabilitation.

The current results suggest that a training programme using TMS or GVS combined with selected physical therapy exercises improved objective measures of bilateral postural stability in geriatrics parkinsonian patients. This improvement occurred in a phase (after one year post PD) when significant motor recovery or neurological gains are poorly expected. It may be important to associate TMS and GVS to conventional programs.

Conflicts of interest: None

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