The impact of galvanic vestibular stimulation on elderly balance

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Abstract

Background: Imbalance still a common and fatal problem among the elderly population, increasing morbidity and mortality rate in society among the elderly, This study assessed the efficacy of galvanic vestibular stimulation on balance in the elderly.

Subjects and methods: Forty elderly patients of both sexes (23male and 17female) their age ranged from 60 to 70 years old were selected from the outpatient clinic of the Faculty of Physical Therapy, Cairo University. The forty patients were divided into two groups; each group consisted of twenty patients. Group (A) performed a program of balance exercises in addition to galvanic vestibular stimulation 3times/week and group (B) control group performed a program of traditional balance exercises. The balance was assessed at the beginning of the study and after 12 weeks of treatment.

Results: Showed that there are no significant differences (P>0.05) for Biodex scores of both groups as the post- treatment mean values ± SD of the biodex scores for both groups (A and B) were (3.70±1.69 and 4.19±1.70), respectively and no significant differences for functional reaching test scores (P<0.05) as the post- treatment mean values ± SD of functional reaching test scores for both groups (A and B) were (21.61±2.44 and20.26±2.99), respectively.

Conclusion: it was found that galvanic vestibular stimulation was not considered an effective intervention in improving balance in elderly > 60 years.

Key words: galvanic vestibular stimulation, elderly, Balance.

Introduction

Good balance and capacity to walk are imperative skills of ADLs that needs the multifaceted integration of motor, sensory, and cognitive information concerning the body position in relation to the surroundings and adequate motor responses for proper control of movement. Limitations in mobility is often in elderly > 60 years and is related to risk of falling, cognitive impairment, functional independence, hospitalization, frailty, debility and even death. In clinical settings and geriatrics homes, the systematic procedure of balance assessment in the elderly requires the potential to increase the disclosing of vulnerable people, thus decreasing negative health effects such as falls.(1)

Aging is a dynamic phenotype that induces a progressive deterioration in physiological function, which can lead to balance deficits, and it is a significant risk factor for a variety of serious diseases. When comparing healthy older adults to healthy young adults, it was discovered that as the risk of dropping rises above 60 years old, healthy older adults have substantial shortcomings in static and dynamic equilibrium. (2)

Falling in older people is a complicated public health problem that can lead to disability, impairments, and high cost for society and family that need a complex approach to detect the causes and improve effective interventions aiming these populations. Recent researches indicate a higher incidence of falls and anxiety of falling occur between this population (3)

The main risk factors of falling in older adults are age, sex, ethnicity, education, BMI, household finances, pain and visual disorders, functional disability, previous falls, aging, decrease muscle strength , using psychotropic medications, environmental hazards, physical fitness, physical limitations, instrumental limitations, and using of walking aid , medical and emotional factors involving depression, chronic diseases, parkinsonism , medication of hypertension, self-aware poor health. Those who sustained an injury need to receive medical attention and may require hospitalization. These injuries include fractures, head trauma and ligamentous injuries or strains (4)

Falling in the elderly will result in long-term immobility and complications. As a consequence, physical dysfunction occurs in the elderly population due to coordination deficits. Environmental changes and complex postural regulation, as well as adequate recovery following the early detection of balance deficits, may help people avoid falling and improve quality of life. (5)

Postural control is a multifaceted motor skill that involves stability management and environmental orientation. It is the product of a combination of many sensorimotor processes. It is needed for the majority of motor tasks, which are performed simultaneously as people stand to complete a goal-directed mission.(6)

Balance is maintained by integrating sensory input from the vestibular, somatosensory, and visual systems, which is then mediated by the nervous system and muscular system to monitor the body's position in relation to the environment and to keep COG within a stable base of support during movement.(7)

The vestibular system is one of the key mechanisms that controls equilibrium, and it is considered an absolute guide in comparison to the other systems that engage in this role, such as the somatosensory and visual systems**.**(8)

The main consequence of normal aging of the vestibular system is vestibule-ocular reflex degeneration. The main sign of its failure is inability to control balance towards body rotation through affecting walking. The intensive and regular training of this reflex is effective in prevention of falls and balance control.(9)

In vestibular research, galvanic vestibular stimulations become extensively used techniques; in combination with neuroimaging during vestibular stimulation they have enabled researchers to discover the brain areas of the human being. It's advantage that vestibular stimulation can be isolated and can be applied while the body is steady. They produce the perception of body movement although the body remains still**.**(10)

The aim of this study was to see how effective galvanic vestibular stimulation is at improving balance in the elderly.

Subjects and methods:

Subjects:

The present randomised controlled trial was performed in an out-patient clinic at Cairo University's Faculty of Physical Therapy from September 2019 to November 2020 for a duration of 12 weeks. There were forty patients aged from 60 to 70 years old clinically stable mentally and psychologically were included in this study. Patients with Cardio pulmonary disorders, Metabolic disorders (Diabetes Mellitus), Endocrine, thyroid disease or suprarenal disease, Hepatic disorders or renal disorders, any mentality disorders, any neurological disorders , any visual abnormality (e.g cataract, glaucoma)or hearing loss and patients with cochlear implants (and similar devices)were excluded. The patients were fully informed by the physiotherapist and all signed a written informed consent form. The patients were evenly divided into two groups. (1) (Study group A) comprised 20 (10 male and 10 female), their mean ± SD for age were 64.85±2.98 years, were given a regimen of balance training program in addition to galvanic stimulation. (2) (Control group B) comprised 20 patients consisted of twenty participants (13 male and 7 female), their mean ± SD for age were 65.55±3.20 years Practiced a program of traditional balance exercises. And overall stability index, Antero posterior stability were measured before the intervention and after 12week.

Methods:

Assessment tools:

- BIODEX Balance System (20 Ramsey Road Shirley, New York, 11967-4704).
- Functional Reach Test

Therapeutic tools:

1- Galvanic vestibular stimulation (made in Anaheim, California 92805 USA)

Evaluation procedures:

The BIODEX Balance system:

- The test consisted of recording the patient's ability to control the platform variation from a perfectly balanced position. A large variation was indicative of poor control and balance. All patients were given an explanatory session before the evaluation procedure based on the protocols set in the BIODEX system operation manuals to be aware about the different test steps of the BIODEX system. Patients were asked to stand centralized on the locked platform bare feet .Each patient was tested on most stable platform (stability level 8) for 30 s. The patients were informed to try to keep the platform in a centered position (Once the platform start to move) by changing the position of their feet to another position that keeps the cursor on the center of the screen grid at the visual feedback screen.
- Each subject was informed about the whole procedures before testing.
- All subjects were tested bilaterally and with their eyes opened.
- Each subject was instructed to keep the platform level for 20 seconds and then rest for 10 seconds by sitting.
- This high stability level and reduced time was chosen to avoid falling in elderly.
- Each subject was required to complete three practice tests prior to the testing conditions to ensure that they were familiar with the instrument.
- Support rails were adjusted according to the subjects comfort and safety. Display height and tilt were adjusted, so each subject could look straight at it.
- All subjects understood that this instrument would help them to assess their balance.
- The balance platform was locked at the start of each session.
- Make sure the patient is in the middle of the platform.

The test was initiated and the system started recording sway values after introducing heel coordinates and feet angles into the BIODEX system

Functional reach test

Description of functional reach test

The test used a leveled measure tape, mounted on the wall and positioned at the height of the individual's acromion process. The individual stood sideward next to the wall without touching, erect with their feet at shoulder-width apart and one arm elevated to 90° of shoulder flexion with elbow straight and handed fisted. The individual placed his/her closed fist against the wall-mounted measure tape. The initial measurement was made of the position of third metacarpal along the measure tape. After taking the initial measurement, the individuals were instructed to lean forward and slide the fisted hand against the measure tape without losing their balance or moving their feet. A second measurement was also taken using third metacarpal for reference. The difference in the centimeters between the two positions of fist on the measure tape was considered as the functional reach. Three readings were obtained of each individual and average reading was considered for the statistical analysis (11).

Treatment procedures:

Group A: Galvanic vestibular stimulation:

The patient in study group treated with galvanic vestibular stimulation in addition to traditional physical therapy program for balance**.** According to Blanke et al., bipolar galvanic vestibular stimulation with a current of 1 mA amplitude and 2 ms length at 100 HZ stimulates the vestibular system (12).The anode is secured with adhesive tape behind one ear's mastoid process, and the cathode is secured behind the other ear's mastoid process. The ground or reference signal is normally put on the forehead for a short period of time, around 2 minutes. (13). Three sessions per week from sitting on chair with back supported. The duration of sessions lasted for 42 minutes (galvanic stimulation for 2 minutes, 40 traditional balance training.

Safety measures:

Electrical safety is very important during applying GVS in the clinic. The most prevalent side effects are tingling, pain under and nearby the stimulus electrodes, itching, and a recruitment of facial nerve fiber depending on stimulus amplitude. Large surface electrodes were used (1,000 mm2) on the mastoid covered with gel or wet cover to eliminate somatosensory cues that could bias the results reduces skin irritations, patient pain, and burns. Furthermore, GVS is not recommended for patients who have cochlear implants (or related devices) to avoid implant failure due to electromagnetic interference (14)**.**

Group b: Traditional Physical therapy program plus diet regimen:

The workout lasts 40 minutes. The patients in both the control and research groups followed the planned PT program as follow:

1- Stretching exercises of shortened muscles.

2- Facilitation of voluntary motor control & righting and equilibrium reactions.

3- Strengthening exercises for abdominal, back and leg muscles.

4- Balance training on a balance board, standing on roll.

-Heel to toe.

-Stand on one leg.

-Sit to stand.

5- Functional training, gait training using external visual and auditory cues (15).

Statistical analysis:

Data collection:

- Data was collected before and after 12 week of treatment.

Data analysis:

The data were not normally distributed and did not breach the parametric assumption for any of the calculated dependent variables, according to histograms with the normal distribution curve used in descriptive analysis. Furthermore, checking for covariance homogeneity revealed a substantial difference of p values less than 0.05. After removing the outliers, box and whiskers plots of each of the tested variables were developed. The researchers were able to perform non-parametric analysis as a result of these findings. For pairwise comparisons, the Wilcoxon test was used to compare the tested variables within groups, and the Mann-Whitney test was used to compare the tested variables between groups (post hoc test).

Results:

Participants' demographic data for both groups regarding gender, age distribution are presented in table (1), (2)

Subject characteristics:

The Subject characteristics of both groups were summarized in table 1, 2 There was no significant difference concerning gender, age distribution ($p > 0.05$).

Table1, 2: Participants' characteristics:

Table (1): The gender distribution in both groups (A, B)

Gender		Group		Total	Chi square
		A	B		
Male	Count	10	13	23	$X^2 = 2.17$
	%	50%	65%	55%	
Female	Count	10	7	17	

	%	50%	35%	45%	P= 0.34
Total	Count	20	20	40	
	%	100.0%	100.0%	100.0%	NS

X^2: Chi square value. NS: Non Significant

Table (2): The mean ± SD of ages for all groups (A and B)

Item	**Group A**	**Group B**	**p value**	**Significance**
	$\bar{X}$ ±SD	$\bar{X}$ ±SD		
Age (Years)	64.85±2.98	65.55±3.20	0.46	NS

***Significant level is set at alpha level <0.05**

NS: Non Significant $\bar{X}$: mean SD: standard deviation

2. Pair wise Comparisons of Dependent Variables:

2.1-Biodex Scores:

A. Within groups:

The pre and post treatment mean values +SD for Biodex scores in study group A were 4.331.78 and 3.701.69 (Degrees), respectively, as shown in table (3). There was a substantial decrease in the discrepancy between the pre and post treatment mean values SD of Biodex scores (P<0.05).

Finally, the mean SD values of Biodex scores in the "pre" and "post" tests in the control group were 4.221.41 and 4.191.70 (Degrees) respectively in the "pre" and "post" tests, as shown in table (3). (B). There was no statistically significant difference (P-value >0.05) between the pre- and post-treatment mean values SD of Biodex ratings.

Table (3): Pre and post treatment mean values of Biodex scores within both groups (A and B):

Biodex Scores (Degrees)	**Means ± SD**	**Means ± SD**	**Z value**	**P- value**
	Pre test	**Post test**		
Group A	**4.33±1.78**	**3.70±1.69**	**2.04**	**0.041***
Group B	**4.22±1.41**	**4.19±1.70**	**0.298**	**0.75**

***Significant level is set at alpha level <0.05 SD: standard deviation**

B. Between Groups:

Table (4) shows that when the "pre" test mean values of groups (A) and (B) were compared pairwise, there were no substantial differences (P=0.73). Furthermore, there were no substantial differences between group (A) and group (B) when the "post" test mean values were compared pairwise (P=0.16).

Table (4): Pre and post treatment mean values of Biodex scores between groups (A and B):

Biodex Scores (Degrees)	Means ± SD	Means ± SD	Z value	P- value
	Pre test	Post test		
Group A	4.33±1.78	3.70±1.69	2.04	0.041*
Group B	4.22±1.41	4.19±1.70	0.298	0.75
Z value	-0.34	-1.42		
P value	0.73	0.16		

***Significant level is set at alpha level <0.05 SD: standard deviation**

2.2- Functional Reaching Test (FRT) Scores:

A. Within groups:

In the sample group (A), the mean SD values of functional reaching test scores in the "pre" and "post" tests were 19.892.23 and 21.612.44 (cm) respectively in the "pre" and "post" tests, as shown in table (5).There was a substantial improvement (P<0.05) in the gap between the pre and post treatment mean values SD of functional reaching test scores.

Finally, as shown in table (5), the mean SD values of functional reaching test scores in the "pre" and "post" tests in the control group (B) were 20.012.64 and 20.262.99 (cm) respectively in the "pre" and "post" tests. There was no statistically significant difference (P-value >0.05) between the pre- and post-treatment mean values SD of functional reaching test scores.

Table (5): Pre and post treatment mean values of functional reaching test scores within both groups (A and B):

Functional reaching test scores (cm)	Means ± SD	Means ± SD	Z value	P- value
	Pre test	Post test		
Group A	19.89±2.23	21.61±2.44	-2.45	0.014*
Group B	20.01±2.64	20.26±2.99	0.23	0.82

***Significant level is set at alpha level <0.05 SD: standard deviation**

B. Between Groups:

Table (6) shows that when the "pre" test mean values of groups (A) and (B) were compared pairwise, there were no significant differences (P=0.99). Furthermore, there were no significant differences between group (A) and group (B) when the "post" test mean values were compared pairwise (P=0.08).

Table (6): Pre and post treatment mean values of functional reaching test scores between groups (A and B):

Functional reaching test scores (cm)	Means ± SD	Means ± SD	Z value	P- value
	Pre test	Post test		
Group A	19.89±2.23	21.61±2.44	-2.45	0.014*
Group B	20.01±2.64	20.26±2.99	0.23	0.82
Z value	-0.01	1.74		
P value	0.99	0.08		

***Significant level is set at alpha level <0.05** **SD: standard deviation**

Discussion:

This research was performed to determine the effect of galvanic stimulation on balance in elderly people. Falling in older adults is a complex public health problem that can result in disabilities, impairments, high costs to community and families, and even death.

By comparing the mean values after therapy of the assessed variables regarding biodex scores and functional reach test scores, the results of our study showed that findings could not determine that galvanic vestibular stimulation is an effective intervention in the improvement of balance in community-dwelling older adults over 60 years, There was no major difference in the mean values after therapy between the two groups (A, B) (P>0.05). However, variations between pre / post mean values of biodex balance score and FRT were substantial in group A, indicating that GVS improves vestibular recovery and should be included in balance rehabilitation programs for the elderly. Since physical workouts were deemed exhausting, monotonous, and repetitive, as well as noncompliance with the full-time exercise schedule, there were no substantial differences between pre / post mean values of Biodex balance score and FRT in group (B).

The study was hampered by subjects' cooperation in the exercise program, a smaller sample size, physical status and behaviors of subjects not specified in the research protocol, and the withdrawal of some volunteers during the study, all of which influenced the findings in some way.

Vestibular compensation is an effective recovery after partial or total dysfunction of the semicircular canals or macular receptors in the inner ear. There is no physical compensation for peripheral vestibular injury, and the loss results in various functional deficiencies such as dizziness and gait instability. Functional recovery is achieved by neural plasticity by improving neuronal conductivity and neural system strength by changing synaptic weight strength. The neural basis for compensation has been explored generally by vestibulo-ocular reflex (VOR). Furthermore, the study of induced neuroplasticity is closely linked to the mechanism of recent medical treatments involving electrical stimulation, such as deep brain stimulation (DBS) or galvanic vestibular stimulation (GVS).(16)

Repeated electrical stimulation was found to increase the number of glutamate receptors in a previous study. The number of glutamate receptors, which play a critical role in neural plasticity, was changed by repeating electrical stimulation over a short period of time, resulting in neural plasticity. Furthermore, in previous research, the neuroplasticity induced by electrical stimulation was better reported than that induced by motor exercise. As a result, various forms of electrical stimulation showed high effectiveness in producing neuroplasticity.(16)

Following repeated application of GVS for 30 minutes, Fujimoto et al. (17) demonstrated that GVS has a major impact on postural stability that lasts for many hours in stable older people.

The studies of Stefani et al., (18) showed the performance improvements in vestibular outputs measures .Also, enhancement in static, dynamic balance or vestibulo-ocular function after application of GVS.

The study done by Smith et al., (19) suggested that galvanic vestibular stimulation significantly improve canal strength. GVS affects vestibular hair cells and changes the firing rate of vestibular afferents that innervate beneath mastoids and fire brainstem nuclei, stimulating sensory system-related cortical and subcortical regions.

Ahmed et al. (20) discovered that galvanic stimulation improved canal paresis, implying that vestibular rehabilitation trainings can trigger neurophysiological properties. These findings contradict those of Ricci et al. (21) who stated that VRT is essential in achieving vestibular compensation through central neuroplasticity mechanisms in order to alleviate vestibular symptoms. Movement activates other sensory signals, as can be shown (visual, proprioceptive, and somatosensory systems).

Regarding postural stability, the study of Ahmed et al., (20) illustrated no significant difference was detected between study and control groups in post- treatment values. Since there was a substantial improvement in all parameters in the sample group after treatment, the control group's preference scores increased as well. These findings corroborated those of Kataoka et al. (22) who found that trans-mastoid galvanic stimulation improved axial motor proprieties and postural unsteadiness in parkinsonian patients. Nooristani et al. (23) also indicated that after 30 minutes of nGVS, postural equilibrium results in a continuous post-stimulation enhancement.

Furthermore, Fujimoto et al. (24) investigated the properties of n GVS's long-term efficacy on static postural steadiness in patients with benign positional dizziness and discovered that nGVS has a fantastic post-stimulation effect on postural stability. Barozzi et al. (25) used static post-urography and the vertigo handicap inventory short form to compare the effects of oculomotor rehabilitation on static balance and a vertigo handicap to the effects of a vestibular electrical stimulation in 28 patients. They found no major differences between before and after treatment, indicating that both treatments are valid.

In another study, patients who received galvanic stimulation showed improvements in the visual, vestibular, and somatosensory constituents of post urography after treatment, while those who received vestibular rehabilitation exercises revealed enhancement in the preference portion. Barozzi et al. (25) explained that oculo-motor exercise (Cawthorne Cooksey eye movements and gaze stabilization trainings) stimulating extra-ocular muscle proprioceptors can provide somatosensory supplementary indicators affecting postural stability, while GS stimulates vestibular nuclei through the spino-vestibular pathways.

Aw et al. (26), who provided 40 patients with a combination of conventional vestibular rehabilitation and galvanic vestibular stimulation, found that they improved significantly more than those who only received traditional vestibular rehabilitation. To rule out any psychological benefits, the authors used placebo stimulation on participants in the conventional vestibular recovery community, which confirmed the findings.

It was found that galvanic vestibular stimulation was not considered an effective treatment in improving balance in elderly > 60 years.

Ethical consideration:

All participants were told about the study's intent, existence, and potential risks before signing a written informed consent form.

A brief medical history of each subject was taken to ensure that they were not having chronic cardiac, respiratory problems, psychiatry or psychological disorders or advanced

musculoskeletal disorders that might restrict and influence the results of the study.
Physical Therapy Faculty Committee, University of Cairo, Egypt (No.: P.T.REC /012/002291.

Informed consent:

All participants in this study gave their informed consent before taking part.

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