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Case reports

Galvanic vestibular stimulation to improve postural instability, voluntary attention, and quality of life in Parkinson's disease patients

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ABSTRACT

Galvanic vestibular stimulation (GVS) influences body balance and has proved to be useful to improve patients' mood, quality of life, and cognitive skills. This study aimed to present three cases of patients with Parkinson's disease and postural instability who had been submitted to GVS to improve their balance, by assessing the impact of this intervention on their cognition, mood, and quality of life. Patients were assessed before and after GVS sessions concerning P300 latency and scores on the 15-item Geriatric Depression Scale (GDS-15) and the 39-item quality-of-life Parkinson's Disease Questionnaire (PDQ-39). The three patients' P300 latency improved, possibly indicating improved attention. Their PDQ-39 score also improved, possibly indicating a positive impact on their quality of life. Their GDS-15 score did not change before and after the intervention. None of the patients had any intervention side effects. This three-case experimental pilot study has shown that GVS is a safe method, possibly useful to improve attention and, therefore, the quality of life of patients presented with Parkinson's disease.

Keywords: Parkinson Disease; Postural Balance; Mental Status and Dementia Tests; Quality of Life; Evoked Potentials

Study conducted at Universidade Federal de Minas Gerias, Belo Horizonte, Minas Gerais, Brazil.

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INTRODUCTION

Parkinson's disease (PD) affects various areas of the brain and brainstem[1]. Depression and cognitive dysfunction stand out among its nonmotor manifestations because they greatly interfere with the patients' quality of life[1]. Depression may occur in initial PD phases, even before classic motor manifestations, and it is worse in patients with imbalance[2]. Along with cognitive and mood changes, postural instability is a determinant of worsened quality of life[3].

Voluntary attention is the cognitive skill affected in the initial phases of PD-related cognitive changes and depression[4].

Using P300 is particularly important to test attention changes in the initial PD stages (when these cognitive conditions are subtler)[5]. Hence, this electrophysiological examination, which is a simple and noninvasive procedure, is important to early recognize cognitive dysfunctions in PD patients[2].

Galvanic vestibular stimulation (GVS) is a type of electric stimulation that produces a complex ocular and perceptual motor response to aid the postural rehabilitation process[6]. Studies demonstrate that the efferent vestibular pathways, which send stimuli to the cerebellar vermis via vestibular nuclei, have an important effect on dopaminergic pathways[7]. GVS can activate these efferent pathways in response to vestibular stimulation, as seen in putamen positron emission tomography[3]. Thus, GVS, which is a safe and painless method, can be used as an auxiliary rehabilitation tool to address motor instability, with positive effects on cognition and mood[8].

This study aimed to assess GVS' effects on the mood, cognition, and quality of life of PD patients with postural instability.

CASE PRESENTATION

This study was approved by the Research Ethics Committee of the *Santa Casa de Misericórdia* Hospital of Belo Horizonte, Brazil, under evaluation report no. 4.165.733 and CAEE 28850619.9.3001.5138.

This experimental pilot study approached three patients diagnosed with PD and postural instability submitted to GVS. They were assessed between July and December 2021 and previously selected at a movement disorder outpatient center. All of them had been previously diagnosed with PD, were taking medications, had postural instability, and were submitted to GVS to improve their body balance[9].

This study addressed the effects of GVS on cognition, mood, and quality of life. P300 (auditory cognition), the 15-item Geriatric Depression Scale (GDS-15), and the 39-item quality-of-life PD questionnaire (PDQ-39) were assessed before and after the GVS intervention. The participating patients' hearing was enough to obtain the P300 evoked potential, and they were cognitively intact, as verified with the Mini-Mental State Examination (MMSE), considering the cutoff score equal to or below 24 points to define cognitive decline[10]. Before performing P300, patients were submitted to pure-tone threshold audiometry – having hearing loss above 40 dB in a four-frequency mean (500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz) was an exclusion criterion.

Auditory cognition was electrophysiologically assessed with P300 in a single-channel MASBE/system Act Plus equipment (CONTRONIC, Pelotas, Brazil). Electrodes were positioned according to the international 10-20 system, using electrolytic paste between the skin and electrode to improve electric conductivity. The active electrode was fixed on the forehead midline (Fz); the negative electrodes were fixed on the right (A2) and left (A1) earlobes; and the ground electrode (Fp1) was fixed on the forehead to the left of Fz. The electrodes were connected to the preamplifier, and the maximum impedance was set at 2 kΩ. Auditory stimuli were presented through TDH-39 earphones at 90 dBHL, and participants were instructed to identify and count the rare ones. Altogether, 300 stimuli were presented in each examination, divided into 80% frequent ones at 1000 Hz and 20% rare ones at 2000 Hz. The procedure was repeated at least once to ensure record replicability. The initial screening amplitude was 5 uV, with a 20-Hz low-pass filter, 1-Hz high-pass filter, and 60-Hz filter. It was considered that normal hearing older adults without dementia have P300 values compatible with their age range – i.e., 300 to 340 ms in those 48 to 65 years old and 320 to 360 ms in those 66 to 81 years old[11].

The GDS-15 cutoff score to screen depression was equal to or above 5 points[12].

PDQ-39 assesses the quality of life in PD, with scores ranging from 0 to 100% – the higher the value, the worse the self-perceived quality of life[13].

Tests before and after the intervention

Before being submitted to the GVS protocol, the patients answered MMSE. They were also classified on the Hoehn & Yahr scale regarding their degree of

disability, based on the neurological examination[14]. Hearing loss was characterized based on air-conduction and bone-conduction pure-tone threshold audiometry and the Speech Recognition Index.

Patients were submitted to P300, GDS-15, and PDQ-39 before and after the intervention. The researchers had previously trained the examiners who administered the scales and applied the tests, and the results were blindly analyzed as to whether they were from before or after the intervention.

Galvanic vestibular stimulation (GVS)

The GVS protocol (intervention) had eight weekly sessions, with gradually increasing duration and current intensity, according to the rehabilitation protocol described in Chart 1.

Chart 1. Galvanic vestibular stimulation protocol used for 8 weeks

Number of sessions	1st (1 wk)	2nd (2 wk)	3rd (3 wk)	4th (1 mo)	5th (5 wk)	6th (6 wk)	7th (7 wk)	8th (2 mo)
Stimulation 1	1.0/1.0/3.0	2.0/2.0/3.0	2.0/2.0/5.0	2.0/3.0/5.0	2.5/2.0/5.0	2.5/2.0/5.0	2.5/2.0/5.0	2.5/2.0/5.0
Stimulation 2	1.5/1.0/3.0	2.5/2.0/3.0	2.5/2.0/5.0	2.5/2.0/5.0	3.0/2.0/5.0	3.0/2.0/5.0	3.0/2.0/5.0	3.0/2.0/5.0
Stimulation 3	2.0/1.0/5.0	2.5/2.0/3.0	2.5/2.0/5.0	2.5/3.0/5.0	3.5/2.0/5.0	3.5/2.0/5.0	3.5/2.0/5.0	3.5/2.0/5.0

Captions: wk = weeks; mo = months; (voltage in milliampere/ stimulus duration in minutes/number of stimulus repetition)

GVS was applied with an EVKGVS Galvanic Stimulator (CONTRONIC, Pelotas, Brazil). The stimulation was presented through disposable, adhesive, 3-cm-wide surface electrodes (manufactured by Valutrode, model CF3200), fixed on both mastoid processes, providing binaural and bipolar stimulation. The stimuli were generated by a rectangular current stimulator with pulsed alternating polarity, at an intensity ranging from 1 to 3.5 mA, lasting from 1 to 3 minutes.

RESULTS

The patients' characteristics, time with PD, educational attainment, and pre-intervention examination results are described in Chart 1. The three patients had no history of previous vestibular disease, myelitis, or stroke; they did not have a pacemaker, and their PD medication had not been changed within 30 days before the assessment. Their best-ear hearing thresholds were all compatible with mild sensorineural hearing loss, and none of the patients had abnormal MMSE.

Cases 1 and 2 were on Hoehn & Yahr[14] PD disability stage 3 (bilateral symptoms and moderate postural instability – i.e., the patient is independent but has some functional loss). Case 3 was on stage 4 (important functional disability; stands and walks with help)[15]. Scale and examination results before and after the intervention are shown in Charts 2, 3, and 4.

Chart 2. Information on sex, age, time with the disease, educational attainment, best-ear hearing threshold, and Mini-Mental State Examination

Case	Sex	Age (years)	Time with the disease (years)	Educational attainment (years)	Best-ear mean* hearing threshold (Hz)	MMSE
1	male	77	9	8	30	25
2	male	70	8	4	30	28
3	female	65	11	4	25	27

Caption: MMSE = Mini-Mental State Examination; *considering the three-frequency mean between 500, 1000, and 2000 Hz

Chart 3. Scores of the quality-of-life questionnaire and Geriatric Depression Scale before and after 8 galvanic vestibular stimulation sessions

Tests	GVS	Case 1	Case 2	Case 3
PDQ-39 $^{\mu}$	Before	61	45	62
	After	21	38	40
GDS $^{\rho}$	Before	8	5	4
	After	7	8	2

Captions: PDQ-39$^{\mu}$ = quality-of-life questionnaire; GDS-15$^{\rho}$ = Geriatric Depression Scale; GVS = galvanic vestibular stimulation; μ = higher scores indicate a worse perception of the quality of life; **ρ** = cutoff score ≥ 5 to determine the presence of depressive symptoms in older adults.

Chart 4 shows that the three cases' P300 latency decreased after the intervention, which indicates improved voluntary attention.

Chart 4. Latency and amplitude of the long-latency auditory evoked potential before and after 8 galvanic vestibular stimulation sessions

Examination	GVS	Parameters	Case 1	Case 2	Case 3
P300	Before	Latency (ms)	376.74	379.27	351.51
		Amplitude (μV)	3.15	4.83	5.77
	After	Latency (ms)	328.81	336.38	321.24
		Amplitude (μV)	1.9	11.83	15.8

Captions: ms = milliseconds; μV = microvolts; P300 = long-latency auditory evoked potential; GVS = galvanic vestibular stimulation

DISCUSSION

The three patients in this study had their cognitive parameters improved after GVS.

PD patients have cognitive changes more often[1]. Since dementia can interfere with P300 response, this study only included cognitively intact patients, as screened with MMSE. Hence, it was possible to assess whether any change had taken place in the auditory cognition of patients without dementia, based on the P300 evoked response, after they had been submitted to GVS sessions. P300 latency reflects the auditory processing speed regarding external stimuli, attention, and working memory[16]. The three patients' latency values decreased after the intervention, which possibly indicates an improvement.

This study showed improved GDS-15 scores after the intervention in two patients. A previous study demonstrated that GVS positively impacts mood and anxiety[17]. It has also been observed that GVS quickened the bradykinetic rest-to-active transition in PD[18]. This gain helped improve these patients' quality of life and, consequently, their mood[19,20]. PDQ-39 scores in this study improved after GVS – thus, agreeing with findings in the literature on GVS' positive impact on cognition and mood.

Previous articles have demonstrated that GVS generally influences brain connectivity, possibly improving neural interactions in PD[9,21].

The cerebellar visual network and other pontine/cortical projections derived from the prefrontal, posterior parietal, and temporal lobe cortex and the limbic system are impaired in PD[22]. GVS is believed to promote cognition improvement mechanisms by increasing cerebellar connectivity[9,22].

This study has some limitations concerning GVS effectiveness and efficiency to improve attention and quality of life in PD. It did not analyze a control group receiving placebo stimuli, and its sample size was insufficient for statistical analyses. On the other hand, in a clinical trial design, three cases assessed before and after the intervention make it possible to evaluate safety and tolerability. Paresthesia, itchy skin where electrodes had been fixed, and dysgeusia have been reported as possible GVS side effects[22]. None of the patients in this study complained of possible intervention side effects.

CONCLUSION

The analysis of three cases before and after applying GVS showed that this method is safe, well-tolerated, easy to perform, and possibly useful to improve PD patients' executive function, attention, and, therefore, quality of life and body imbalance.

REFERENCES

1. Galhardo MMAMC, Amaral AKFJ, Vieira ACC. Caracterização dos distúrbios cognitivos na Doença de Parkinson. Rev. CEFAC. 2009(1):251-7. https://doi.org/10.1590/S1516-18462009000600015.
2. Tokic K, Titlic M, Beganovic-Petrovic A, Romac R, Silic S. P300 wave changes in patients with Parkinson's disease. Med Arch. 2016;70(6):453-6. https://doi.org/10.5455/medarh.2016.70.453-456. PMID: 28210020.
3. Boonstra TA, Kooij H Van Der, Munneke M, Bloem BR. Gait disorders and balance disturbances in Parkinson's disease: clinical update and pathophysiology. Current Opinion in Neurology. 2008;(21):461-71. https://doi.org/10.1097/WCO.0b013e328305bdaf. PMID:18607208.
4. Melo LM, Barbosa ER, Caramelli P. Declínio cognitivo e demência associados à doença de Parkinson: características clínicas e tratamento. Rev. Pisq. Clin. 2016;34(4):176-83. https://doi.org/10.1590/S0101-60832007000400003.
5. Titlic M, Mise NI, Pintaric I, Rogosic V, Vanjaka-Rogosic L, Mihalj M et al. The event-related potential P300 in patients with migraine. Acta Inform Medica. 2015;23(6):339-42. https://doi.org/10.5455/aim.2015.23.339-342. PMID: 26862241.
6. Kim G, Lee S, Kim KS. Repeated galvanic vestibular stimulation modified the neuronal potential in the vestibular nucleus. Neural Plast. 2020;2020:5743972. https://doi.org/10.1155/2020/5743972. PMID: 32565777. PMCID: PMC7273393.
7. Barmack NH. Central vestibular system: vestibular nuclei and posterior cerebellum. Brain Res Bull. 2003;60(5-6):511-41. https://doi.org/ 10.1016/s0361-9230(03)00055-8.
8. Lee S, Liu A, McKeown MJ. Current perspectives on galvanic vestibular stimulation in the treatment of Parkinson's disease. Expert Rev Neurother. 2021;21(4):405-18. https://doi.org/10.1080/14737175.2021.1894928. PMID: 33621149.
9. Liu A, Bi H, Li Y, Lee S, Cai J, Mi T et al. Galvanic vestibular stimulation improves subnetwork interactions in Parkinson's disease. J Healthc Eng. 2021;2021:6632394. https://doi.org/10.1155/2021/6632394. PMID: 34094040. PMCID: PMC8137296.
10. Nazario MPS, Silva VHT, Martinho ACDO, Bergamim JSSP. Déficit cognitivo em idosos hospitalizados segundo Mini Exame do Estado Mental (MEEM): revisão narrativa. J Heal Sci. 2018;20(2):131-4. https://doi.org/10.17921/2447-8938.2018v20n2p131-134.
11. Lopes MS, Melo ADS, Nóbrega AC. Delayed latencies of auditory evoked potential P300 are associated with the severity of Parkinson's disease in older patients. Arq Neuropsiquiatr. 2014;72(4):296-300. https://doi.org/10.1590/0004-282X20140005.
12. Yesavage JA, Brink TL, Rose TL, Lum O, Huang V, Adey M et al. Development and validation of a geriatric depression screening scale: a preliminary report. J Psychiatr Res. 1982;17(1):37-49. https://doi.org/ 10.1016/0022-3956(82)90033-4.
13. Navarro-Peternella FM, Marcon SS. Qualidade de vida de indivíduos com Parkinson e sua relação com tempo de evolução e gravidade da doença. Rev Lat Am Enfermagem. 2012;20(2):384-91. https://doi.org/10.1590/S0104-11692012000200023.
14. Shenkman ML, Clark K, Xie T, Kuchibhatla M, Shinberg M, Ray L. Spinal movement and performance of standing reach task in participants with and without Parkinson disease. Phys Ther. 2001;81:1400-11. https://doi.org/10.1093/ptj/81.8.1400.
15. Guimarães MPA, Severino VCB, Pinheiro HA. Correlação entre funcionalidade e gravidade da doença de Parkinson em idosos. Geriatr Gerontol Aging. 2013;7(3):203-7. Disponível em: http://www.ggaging.com/details/142/pt-BR.
16. Ferrazoli N, Donadon C, Rezende A, Skarzynski PH, Sanfins MD. The application of P300-Long-Latency Auditory-Evoked Potential in Parkinson disease. Int Arch Otorhinolaryngol. 2022;26(1):158-66. https://doi.org/10.1055/s-0040-1722250.
17. Pasquier F, Denise P, Gauthier A, Bessot N, Quarck G. Impact of galvanic vestibular stimulation on anxiety level in young adults. Front Syst Neurosci. 2019;13:14. https://doi.org/10.3389/fnsys.2019.
18. Yamamoto Y, Struzik ZR, Soma R, Ohashi K, Kwak S. Noisy vestibular stimulation improves autonomic and motor responsiveness in central neurodegenerative disorders. Ann Neurol. 2005;58:175-81. https://doi.org/10.1002/ana.20574. PMID: 16049932.
19. Wilkinson D, Podlweska A, Sakel M. A durable gain in motor and non-motor symptoms of Parkinson's Disease. NeuroRehabilitation. 2016;38(2):179-82. https://doi.org/10.3233/NRE-161308. PMID: 26889733.
20. Jagadeesan T, Rajagopal A, Sivanesan S. Vestibular stimulation: a noninvasive brain stimulation in Parkinson's disease & its implications. J Complement Integr Med. 2021;18(4):657-65. https://doi.org/10.1515/jcim-2020-0155.
21. Dan X, Hu Y, Sun J, Gao L, Zhou Y, Ma J et al. Altered cerebellar resting-state functional connectivity in early-stage Parkinson's disease patients with cognitive impairment. Front Neurol. 2021 Aug 25;12:678013. https://doi.org/10.3389/fneur.2021.678013. PMID: 34512503.
22. Dilda V, Macdougall HG, Curthoys IS, Moore ST. Effects of galvanic vestibular stimulation on cognitive function. Exp Brain Res. 2012;216(2):275-85.https://doi.org/10.1007/s00221-011-2929-z. PMID: 22076407.

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RCDO: original draft writing, data curation, research conceptualization, review and editing, and methodology;

LL: data curation, formal analysis, and project administration;

PGZM: conceptualization, methodology, and resources;

MLD: conceptualization, methodology, software, and resources;

ANPAP: conceptualization, original draft writing, formal analysis, and resources;

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