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Immediate effect of electrical vestibular stimulation on autonomic and respiratory parameters and reaction time in patients with Parkinson's disease

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ABSTRACT

Background: Both the electrical and natural vestibular stimulation were reported to alter both the blood pressure and motor output of respiration. After a thorough review of the literature, the studies observed the immediate effect of vestibular stimulation on autonomic and respiratory functions is sparse. Hence, the present study was undertaken. **Aims and Objectives:** The present study was undertaken to observe the immediate effect of electrical vestibular stimulation on autonomic and respiratory parameters in patients with Parkinson's disease (PD). **Materials and Methods:** The present study recruited 30 patients with PD after obtaining written informed consent. After recording the baseline values, a single session of stimulation was administered to the participants and soon after recorded the participants. Blood pressure was recorded by Diamond BPDG 141 Deluxe Multicolor LED Mercury Free BP Monitor. Pulse rate and respiratory rate were recorded manually. Auditory and visual reaction times were recorded using the RT apparatus. **Results:** There was a significant decrease in the systolic ($P = 0.011$) and diastolic blood pressure ($P = 0.002$) after the stimulation. The pulse rate was decreased significantly ($P = 0.071$) followed by the vestibular stimulation. No change in the respiratory rate was observed followed by the vestibular stimulation. There was a significant decrease in the visual reaction time for red ($P = 0.0087$) and green light ($P = 0.0007$), as a result of the intervention. Auditory reaction time for low pitch ($P = 0.0056$) was significantly decreased followed by the intervention. **Conclusion:** The study results support that a single session of electrical vestibular stimulation has beneficial effects on blood pressure and reaction time in patients with PD. Further detailed studies are recommended with long-term administration of electrical stimulation to recommend the use of electrical vestibular nerve stimulation in the management of non-motor symptoms in PD patients.

Key words: Blood pressure; Vestibular apparatus; Balance; Respiratory rate; Non-invasive stimulation

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INTRODUCTION

Vestibular stimulation has been emerging as an adjunctive therapy in managing many neurological disorders including autonomic dysfunctions leading to alteration of the blood pressure and flow to the vital structures mainly to the brain. It was reported that vestibular stimulation improves blood supply to the brain. This is especially activating

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the otolith organs and this action is not dependent on the blood pressure and blood carbon dioxide changes.[1] Interestingly, it was reported that blocking the vestibular signals causes an increase in the incidence of postural hypotension.[2] Both the electrical and natural vestibular stimulation were reported to alter both the blood pressure and motor output of respiration. Further, it was reported that during the movements, the vestibular signals play a key role in regulating blood pressure and respiration.[3] Animal experiments have confirmed the existence of vestibule-sympathetic and vestibulo-respiratory reflexes.[4] Multiple inputs were identified to vestibular nuclei participating in the autonomic regulation.[5] Vestibular dysfunction was linked with autonomic disorders and anxiety disorders.[6] There is a different observation regarding the effect of vestibular stimulation on the respiratory rate. Some studies explained that the vestibular stimulation followed no change in respiration.[7,8] After a thorough review of the literature, the studies observed the immediate effect of vestibular stimulation on autonomic and respiratory functions is sparse. Hence, the present study was undertaken.

Aims and objectives

The present study was undertaken to observe the immediate effect of electrical vestibular stimulation on autonomic and respiratory parameters in patients with Parkinson's disease.

MATERIALS AND METHODS

The present study recruited 30 patients with Parkinson's disease (PD) after obtaining written informed consent. The participants underwent a thorough physical examination by a general physician and neurologist. Both male and female willing participants in the 40–80 age group who had been diagnosed with PD and have been on treatment for the past 2 years were part of the study. Participants with any severe complications were excluded from the study. The study protocol was approved by the institutional human ethical committee (IEC Ref no-124/2019). The Modius Mood device is a transdermal neurostimulation product. It consists of a battery-powered headset designed to deliver low-level energy in the form of a neurostimulation waveform that modulates the activity of the vestibular cranial nerve (Figure 1). The active Modius Mood device utilizes a technology called electrical vestibular nerve stimulation (VeNS). In the envisaged configuration the device will be placed on the head in a manner analogous to headphones. It will deliver a small electrical current (a maximum of 1.5 mA) to the skin behind the ears over the mastoid processes. The device is powered by a single 3.75V battery, rechargeable through a micro-universal serial bus cable. The device was worn by the subject for 30 min per session for the duration of the trial. The electrode pads are

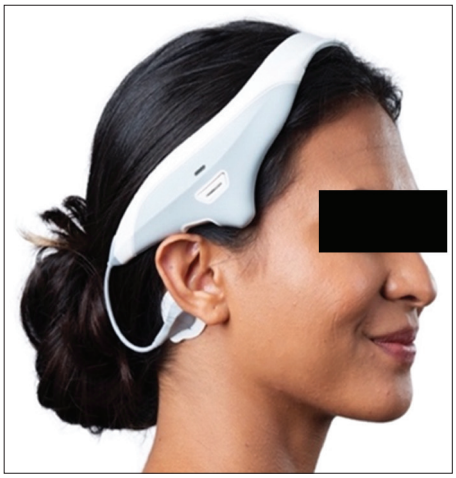

Figure 1: Photograph of the device shows the headset-style design and mastoid electrode placement

positioned on the skin over each mastoid process, behind their ears. When correctly positioned the headset should be switched on using the on/off button. When initially switched on, the default stimulation level is 0 mA (Level 0). The user then increases the stimulation in 0.1 mA increments until the desired level is reached. There are a total of 15 levels. The maximum current delivery is limited to 1.5 mA (Level 15). After recording the baseline values, a single session of stimulation was administered to the participants and soon after recorded the participants. Blood pressure was recorded by Diamond BPDG 141 Deluxe Multicolor LED Mercury Free BP Monitor. Pulse rate and respiratory rate were recorded manually. Auditory and visual reaction times were recorded using RT apparatus manufactured by Anand Agencies, Shukrawar Peth, Pune, Maharashtra.

Statistical analysis

Data were analyzed using the SPSS 21.0 version. Student's t-tests were applied to observe the significance of the difference in the parameters before and after the stimulation. A probability value of <0.05 was considered significant.

RESULTS

Demographic data are presented in Table 1. There was a significant decrease in the systolic and diastolic blood pressure after the stimulation. The pulse rate was decreased significantly followed by the vestibular stimulation. No change in the respiratory rate was observed followed by vestibular stimulation (Table 2). There was a significant decrease in the visual reaction time for red and green light, because of the intervention. Auditory reaction time for low pitch was significantly decreased followed by the intervention. Auditory reaction time for high pitch was decreased but not statistically significant (Table 3).

Table 1: Demographic parameters of the participants

Parameter	Mean±SD
Age (years)	57.73±9.60
Height (cm)	165±9.7
Weight (kg)	70.57±10.83

Data were expressed as mean and SD

Table 2: Comparison of the autonomic and respiratory parameters before and after the stimulation

Parameter	Before	After	P-value
Systolic blood pressure (mmHg)	137.33±8.8	131±8.3	0.011*
Diastolic blood pressure (mmHg)	91.8±6.8	83.1±4.5	0.002**
Pulse rate (per minute)	85.45±8.43	80.2±6.3	0.071*
Respiratory rate	11.58±2.8	12.63±1.9	0.169

Data were expressed as mean and SD. (*P<0.05 was significant. **P<0.01 is significant)

Table 3: Comparison of the auditory and visual reaction time before and after the stimulation

Parameter	Before	After	P-value
Visual reaction time – red light	1.729±0.16	1.357±0.27	0.0087**
Visual reaction time – green light	1.571±0.160	1.071±0.243	0.0007**
Auditory reaction time – high pitch	1.029±0.214	0.8±0.258	0.0964
Auditory reaction time – low pitch	1.343±0.199	0.971±0.214	0.0056**

Data were expressed as mean and SD. (*P<0.05 was significant. **P<0.01 is significant)

DISCUSSION

To the best of our knowledge and thorough review of the literature in PubMed revealed that the studies observed the immediate effect of vestibular stimulation in PD patients. Recent studies administered electrical VeNS to PD patients and observed beneficial effects.[9,10] It was reported that cold water vestibular stimulation in healthy males does not show any significant effect on autonomic activity.[11] Interestingly, both caloric and galvanic stimulations are effective in the management of both motor and non-motor symptoms in patients with PD patients. However, the exact mechanism is yet to be known.[12] Nodulation of the muscle sympathetic activity was reported followed by the transcranial stimulation.[13] Spinning in clock wise direction causes a decrease in vagal activity whereas anticlock wise causes no effect on vagal activity was reported.[14] Galvanic vestibular stimulation was reported to be an effective therapy in the management of postural instability in patients with PD.[15] Dec reased blood pressure was reported followed by the non-invasive electrical VeNS in the patients with diabetes mellitus. Vestibular stimulation was reported to inhibit the sympathetic locus ceruleus, stimulate the dorsal motor nucleus of the vagus, and reduce blood pressure within normal limits.[16] In the present study, there was a significant decrease in the systolic and diastolic blood pressure and pulse rate after the stimulation. Further, the studies on the effect of vestibular stimulation on the alteration of respiratory functions are sparse. Few studies reported that no change in the respiratory functions was observed followed by the vestibular stimulation.[8,17] Another study reported that respiratory functions were altered followed by vestibular stimulation in humans.[18] In the present study, no change was observed in the respiratory functions followed by the vestibular stimulation.

It was reported that attention and reaction time were improved significantly followed by the stimulation of the vestibular system in patients with head injury.[19] Interestingly, altered neuronal activity in the brain structures such as the cerebellum, basal ganglia, and limbic system was observed followed by vestibular stimulation.[20] The neuronal processing is influenced by vestibular stimulation for the tasks related to cognitive functions.[21] As the vestibular stimulation influences the limbic system, emotional behavior, and decision-making are regulated by the vestibular system.[22] Further, motor execution is altered by vestibular stimulation through its connections with the cortical areas.[22] In the present study, there was a significant improvement in visual and auditory reaction time followed by single-session vestibular stimulation in PD patients. The study results are in accordance with earlier studies.

Limitations of the study

The study has a less sample size, so the results may not be generalized.

CONCLUSION

The study results support that a single session of electrical vestibular stimulation has beneficial effects on blood pressure and reaction time in patients with PD. Further detailed studies are recommended with long-term administration of electrical stimulation to recommend the use of electrical VeNS in the management of non-motor symptoms in PD patients.

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REFERENCES

1. Serrador JM, Schlegel TT, Black FO and Wood SJ. Vestibular effects on cerebral blood flow. BMC Neurosci. 2009;10:119.
   https://doi.org/10.1186/1471-2202-10-119
2. Shaikh AG, Ghasia FF, Dickman JD and Angelaki DE. Properties of cerebellar fastigial neurons during translation, rotation, and eye movements. J Neurophysiol. 2005;93(2):853-863.
   https://doi.org/10.1152/jn.00879.2004
3. Yates BJ and Miller AD. Physiological evidence that the vestibular system participates in autonomic and respiratory control. J Vestib Res. 1998;8(1):17-25.
4. Yates BJ. Vestibular influences on the autonomic nervous system. Ann N Y Acad Sci. 1996;781:458-473.
   https://doi.org/10.1111/j.1749-6632.1996.tb15720.x
5. Yates BJ. Autonomic reaction to vestibular damage. Otolaryngol Head Neck Surg. 1998;119(1):106-112.
   https://doi.org/10.1016/S0194-5998(98)70179-2
6. Furman JM, Jacob RG and Redfern MS. Clinical evidence that the vestibular system participates in autonomic control. J Vestib Res. 1998;8(1):27-34.
7. Javaid A, Chouhna H, Varghese B, Hammam E and Macefield VG. Changes in skin blood flow, respiration and blood pressure in participants reporting motion sickness during sinusoidal galvanic vestibular stimulation. Exp Physiol. 2019;104(11):1622-1629.
   https://doi.org/10.1113/EP087385
8. Omlin X, Crivelli F, Heinicke L, Zaunseder S, Achermann P and Riener R. Effect of rocking movements on respiration. PLoS One. 2016;11(3):e0150581.
   https://doi.org/10.1371/journal.pone.0150581
9. Kumar Goothy SS, Gawarikar S, Choudhary A, Govind PG, Purohit M, Pathak A, et al. Effectiveness of electrical vestibular nerve stimulation on the range of motion in patients with Parkinson's disease. J Basic Clin Physiol Pharmacol. 2022;34(6):791-795.
   https://doi.org/10.1515/jbcpp-2022-0138
10. Kumar Goothy SS, Gawarikar S, Choudhary A, Gajanan Govind P, Purohit M, Pathak A, et al. Effectiveness of electrical vestibular nerve stimulation as adjunctive therapy to improve the cognitive functions in patients with Parkinson's disease. J Basic Clin Physiol Pharmacol. 2022;34(1):77-82.
    https://doi.org/10.1515/jbcpp-2022-0066
11. Aghababaei Ziarati M, Taziki MH and Hosseini SM. Autonomic laterality in caloric vestibular stimulation. World J Cardiol. 2020;12(4):144-154.
    https://doi.org/10.4330/wjc.v12.i4.144
12. Wilkinson D. Caloric and galvanic vestibular stimulation for the treatment of Parkinson's disease: Rationale and prospects. Expert Rev Med Devices. 2021 Jul;18(7):649-655.
    https://doi.org.10.1080/17434440.2021.1935874
13. McCarthy B, Datta S, Sesa-Ashton G, Wong R, Henderson LA, Dawood T, et al. Non-additive effects of electrical stimulation of the dorsolateral prefrontal cortex and the vestibular system on muscle sympathetic nerve activity in humans. Exp Brain Res. 2024;242(7):1773-1786.
    https://doi.org/10.1007/s00221-024-06852-5
14. Yang AH, Khwaounjoo P and Cakmak YO. Directional effects of whole-body spinning and visual flow in virtual reality on vagal neuromodulation. J Vestib Res. 2021;31(6):479-494.
    https://doi.org/10.3233/VES-201574
15. Kataoka H, Okada Y, Kiriyama T, Kita Y, Nakamura J, Morioka S, et al. Can postural instability respond to galvanic vestibular stimulation in patients with Parkinson's disease? J Mov Disord. 2016;9(1):40-43.
    https://doi.org/10.14802/jmd.15030
16. Goothy SS, McKeown J, Mcgeoch PD, Srilatha B, Vijayaraghavan R, Manyam R, et al. Electrical vestibular nerve stimulation as an adjunctive therapy in the management of type 2 diabetes. J Basic Clin Physiol Pharmacol. 2020;32(6):1075-1082.
    https://doi.org/10.1515/jbcpp-2020-0210
17. Teenumol MJ, Sailesh KS, Johny M, Archana R and Mukkadan JK. Impact of linear vestibular stimulation on respiratory endurance. Res J Pharm Tech. 2017;10(6):1691-1696.
    https://doi.org/10.5958/0974-360X.2017.00299.2
18. Monahan KD, Sharpe MK, Drury D, Ertl AC and Ray CA. Influence of vestibular activation on respiration in humans. Am J Physiol Regul Integr Comp Physiol. 2002;282(3):R689-R694.
    https://doi.org/10.1152/ajpregu.00568.2001
19. Engberg A. Vestibular stimulation after head injury: Effect on reaction times and motor speech parameters. Arch Phys Med Rehabil. 1989;70(13):893-901.
20. Yamamoto Y, Struzik ZR, Soma R, Ohashi K and Kwak S. Noisy vestibular stimulation improves autonomic and motor responsiveness in central neurodegenerative disorders. Ann Neurol. 2005;58(2):175-181.
    https://doi.org/10.1002/ana.20574
21. Furman JM, Redfern MS, Fuhrman SI and Jennings JR. Visual-vestibular stimulation influences spatial and non-spatial cognitive processing. J Vestib Res. 2012;22(5-6):253-259.
    https://doi.org/10.3233/VES-2012-00460
22. Preuss N, Mast FW and Hasler G. Purchase decision-making is modulated by vestibular stimulation. Front Behav Neurosci. 2014;8:51.
    https://doi.org/10.3389/fnbeh.2014.00051

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