Acoustic Measures in Parkinson's Disease Before and After Transcutaneous Vagus Nerve Stimulation:

A Case Study

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Abstract

- Transcutaneous vagus nerve stimulation (tVNS) has been reported to be effective in reorganizing the neural network in the central nervous system and improving the flexibility and movement of the laryngeal muscles.
- This case study aimed to investigate the effect of tVNS on the speech of one participant diagnosed with hypokinetic dysarthria secondary to Parkinson's disease.
- The preliminary results observed increased fundamental frequency and vocal loudness and decreased perturbations manifested in jitter and shimmer. Clinical application of tVNS was implied as an adjuvant treatment in speech and voice disorders.

Introduction

- Parkinson's disease (PD) is a neurological condition caused by the degeneration of the midbrain's substantia nigra, and the common symptoms include tremors, muscle stiffness, slowness of movement, and impaired balance and coordination (Jankovic, 2008).
- Eighty-nine percent of the people with PD may develop hypokinetic dysarthria (Ramig et al., 2018).
- The evaluation of speech and vocal disorder in PD is recommended to include acoustic measures of vocal sound level, vocal frequency, measures of noise in the vocal signal (Patel et al., 2018).

- Transcutaneous vagus nerve stimulation (tVNS) is a non-invasive technique that applies electrical currents through surface electrodes at selected locations to reorganize the brain neural network based on neuroplasticity (Yap et al., 2020).
- The effect of tVNS has been reported on the fine motor movement control of the laryngeal muscles, facilitating motor learning of complex activities (Li et al., 2023).

Purpose

- The purpose of this study is to compare acoustic measures before and after transcutaneous vagus nerve stimulation in one participant with Parkinson's disease.
- It is hypothesized that after receiving tVNS, laryngeal muscle conditions will be improved as manifested in improved acoustic measures.

Methodology

Participant
- One male participant diagnosed with PD, aged 64, no cognitive impairment as screened with MoCA (Nasreddine et al., 1995).

Equipment
- VitalStim Plus was adopted for electrical stimulation with waveforms consisting of 15 biphasic square-wave pulses (150 μs pulse width) delivered at a rate of 25 Hz with an intensity of 7.5 mA determined by the participant as the highest intensity at his comfortable level.

Procedure
- 16 sessions of transcutaneous vagus nerve stimulation, 20 minutes each session, 4 days a week for 4 weeks.
- tVNS stimulation intensity was determined at his comfortably strongest intensity level of 7.5 mA.

Data Collection and Analysis
- Sound samples were collected at pre- and post-treatment (Pre, Post) with the KayPentax Computer Speech Laboratory (CSL Model 4500b), using a head-mounted Countryman microphone, Model E6IOP5T1.
- Praat (Version 6.2.23; Boersma & Weenink, 2022) was utilized for acoustic measurement.
- The acoustic measures included vocal frequency, vocal sound level, and cepstral peak prominence from sustained /a:/ (AH), the entire Rainbow Passage (RBP), and six CAPE-V sentences (Sentence)
- Visual inspection aids of level, variability, and trend were generated with R (Version 4.2.2; R Core Team, 2022) following Manolove et al. (2019).

Results

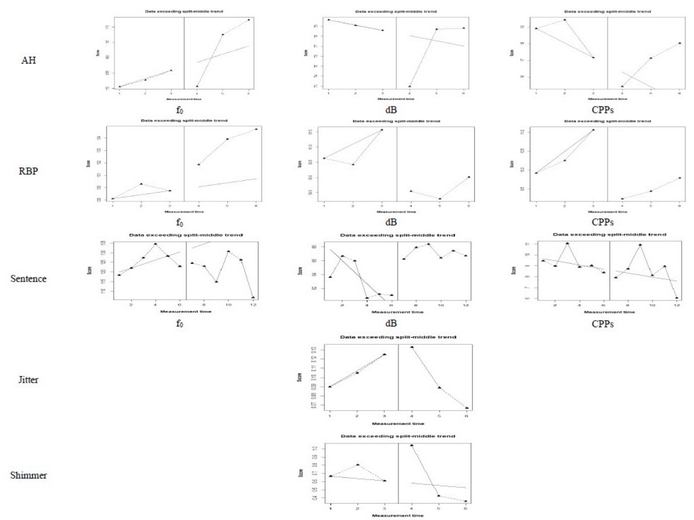
- Table 1 presents the acoustic measures for sustained vowel /a:/, the Rainbow Passage, and the CAPE-V sentences from pre- and post-treatment.
- Results were averaged across trials for AH, RBP, Sentence, Jitter and Shimmer at each measurement period.
- The graphed data of acoustic measures were visually inspected for the level, variability, trend and data points exceeding the median (PEM) within and across the conditions as shown in Figure 1.

Table 1 *Acoustic measures before and after tVNS: Mean (SD)*

	AH			RBP			Sentence			Jitter (rap%)	Shimmer (apq3%)
	F0 (Hz)	dB	CPPs (dB)	F0 (Hz)	dB	CPPs (dB)	F0 (Hz)	dB	CPPs (dB)		
Pre	153.02 (2.57)	79.12 (2.50)	18.50	129.72 (19.03)	60.87 (12.4)	10.41	125.60 (15.35)	63.18 (8.49)	9.30	0.11	0.69
Post	163.5 (4.71)	76.84 (2.23)	16.86	133.49 (24.48)	59.61 (11.90)	9.49	121.03 (28.56)	67.21 (6.93)	8.45	0.10	0.61

- The graphed data of acoustic measures were visually inspected for the level, variability, trend and data points exceeding the median (PEM) within and across the conditions as shown in Figure 1

Figure 1 *Data points exceeding the median (PEM)*



Conclusion /Discussion

- Preliminary results demonstrated that after tVNS, the participant's fundamental frequency has increased, with less perturbation manifested in decreased jitter.
- The participant's vocal sound level increased with less perturbation shown in decreased shimmer.
- Based on findings, it is expected to observe more positive effects of tVNS with the completion of data analysis.
- The results implied the clinical practice with the application of tVNS as an adjuvant in treating speech and voice disorders.

Selected References

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