

Analysis of Short Term Phonatory Stability in Individuals with Parkinson's Disease

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Abstract

The voice abnormality in individuals with Parkinson's disease reflects impaired neuromuscular coordination. Phonatory stability in individuals with Parkinson's disease can be measured acoustically for identifying the voice abnormalities. In the current study, phonatory stability in individuals with Parkinson's disease was measured through acoustic analysis by using PRAAT software. The values of acoustic parameters were compared between normals and individuals with Parkinson's disease. The parameters assessed were mainly F_0 , jitter, and shimmer parameters. The results of the study indicated higher jitter and shimmer parameters in individuals with Parkinson's disease as compared to that of normals. Hence, it can be concluded that voice abnormalities are reflected in individuals with Parkinson's disease.

Key words: Phonatory stability, Acoustic analysis, Parkinson's disease

Introduction

Dysarthria is a group of motor speech disorder caused by weakness, paralysis, slowness, incoordination or sensory loss in a muscle group responsible for speech. Hypokinetic dysarthria is a type of dysarthria which is mainly associated with Parkinson's disease (PD). PD is a neurodegenerative disease affecting the central nervous system. Nowadays, in the elderly population, who are above the age of fifty, the occurrence of PD is found to be more common (Fahn, 2010).

In PD, degradation of dopaminergic neurons of basal ganglia in the nervous system has been found as the main causative factor for its occurrence. This can lead to impairment in motor movements, initially affecting the limb movements. While considering the movement of limbs Lees, Hardy, and Revesz (2009) found that the most common symptom related to movement in individuals with Parkinson's disease are bradykinesia (slowness of movement), resting tremor, rigidity and difficulty in walking.

As stated earlier, the occurrence of PD will lead to inappropriate neuromuscular control in individual, which tend to affect on coordination of muscles responsible for production of speech, voice, articulation, and swallowing. Hence, the speech of these individuals are characterized by monotony of pitch and loudness, reduced loudness and stress, imprecise articulation, variable rate and short rushes of speech, inappropriate silences, and a harsh and breathy voice (Darley, Aronson, & Brown, 1969).

It is reported in literature that alteration in speech production, such as imprecise articulation, decreased rate of speech, reduced vocal intensity and lower variation of fundamental frequency, are observed in individuals with Parkinson's disease (Azevedo, Cardoso & Reis, 2003). These findings were similar to that reported by Ramig, Fox and Sapir, (2008) indicating speech impairment like hypophonia, monotone and dysarthria in individuals with PD. Hanson, Geratt, and Ward (1984) found that the voice quality was more breathy or rough in individuals with PD. The intonation in speech was reported to be monotonous in individuals with PD and this was observed as a reduction in pitch and loudness variation (Aronson, 1990).

The studies have indicated that voice abnormalities are present in individuals with PD. However, there have been limited studies regarding the voice abnormalities in individuals with PD. Thus, obtaining the acoustic parameters that indicates phonatory stability, will add on to the limited Indian research regarding voice abnormalities in individuals with PD. This brings to the need of the present study of analyzing phonatory stability in individuals with Parkinson's disease.

Method

The present study aimed at comparing acoustic parameters between individuals with PD and normal individuals.

Participants

A total of 20 participants were included in this study. They were divided into two groups: Group1 consists of 10 individuals with PD (6 males and 4 females) (aged between 50 and 70 years, mean of 60.1 years) and Group2 included age and gender matched normal individuals.

Inclusion Criteria

According to the Hoehn and Yahr (1967) Staging of Parkinson's disease, six individuals with PD were on the stage 2 and four individuals with PD on the stage 1 of the development of Parkinson's disease. This indicates presence of minimal and mild features of Parkinson's disease in these individuals. The subjects present in the group1 were diagnosed by the neurologist after fMRI/CT scan/other necessary evaluation. Voice was recorded in the early morning to avoid the medicine effect. The onset of the disease was from 1 to 3 years. The criterion for selecting individuals in group 2 was, they should not be having any history of laryngeal surgery or sensory/cognitive problems. Mini mental examination (Folstein, Folstein, & McHaugh, 1975) was done to rule out cognitive deficits, if any.

Procedure and Instrumentation

The voice of the participants was recorded in a quiet environment. All the individuals were instructed verbally regarding the test and verbal consent were obtained. Headphone with microphone facility (Logitech H110) was used for recording the voice sample. The microphone was attached to the laptop (Dell INSPIRON, Intel Core i3 with RAM 2GB, windows 7 Home basic). The acoustic analysis was carried out by using PRAAT software.

Instruction and Stimuli

The subjects were instructed to take a deep breath and to sustain the phonation of vowels (/a/, /i/ & /u/) as long as possible. The phonation of these vowels was recorded and analyzed

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using PRAAT software. The investigated parameters in the present study were: fundamental frequency (F_0), which corresponds to the number of vibration cycles per time unit, parameters of jitter which indicates variation in fundamental frequency variability in the short term while the shimmer parameters indicates an index of variability of the sound wave amplitude in the short-term; noise to harmonic ratio (HNR), which computes the noise in a series of pulses produced by the oscillation of the vocal folds.

Results

The mean value of acoustic parameters obtained in the study is represented in the Table 1. MANOVA was carried out to compare the acoustic parameters between the performance of normal individuals and the individuals with PD.

Table1

Mean and SD values of acoustic parameters in individuals with PD and normals

Parameter		Parkinson's Disease		Normal	
		Mean	SD	Mean	SD
F0	a	158.26	65.89	168.93	33.56
	i	169.17	62.39	178.56	34.64
	u	171.43	53.08	179.91	34.59
Jloc(%)	a	1.08	1.05	.37	.13
	i	.73	.52	.36	.15
	u	.49	.16	.31	.10
Jabs	a	90.90	110.68	22.42	7.00
	i	55.07	53.36	20.54	7.95
	u	32.69	19.50	25.16	21.37
Jrap(%)	a	.62	.59	.22	.07
	i	.40	.30	.19	.08
	u	.28	.10	.17	.05

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Jppq5	a	.60	.61	.22	.08
	i	.45	.29	.22	.10
	u	.29	.10	.18	.05
Jddp	a	1.89	1.77	.64	.25
	i	1.22	.94	.60	.25
	u	.84	.31	.52	.18
Sloc (%)	a	7.12	4.46	3.95	2.11
	i	6.68	6.34	5.00	2.33
	u	4.33	2.00	3.97	1.60
SdB	a	1.60	.39	.34	.18
	i	.57	.55	.43	.21
	U	.38	.17	.34	.13
Sapq3 (%)	a	4.08	2.53	2.22	1.13
	i	3.72	3.61	2.73	1.21
	a	2.45	1.16	2.23	.90
Sapq5 (%)	a	4.28	2.62	2.52	1.43
	i	4.15	3.42	3.37	1.74
	u	2.79	1.30	2.55	1.05
Sapq11 (%)	a	4.94	3.10	2.80	1.48
	i	4.90	4.65	3.68	1.89
	u	3.16	1.39	2.85	1.19
Sdda	a	12.25	7.61	6.68	3.39
	i	11.18	10.86	8.22	3.64
	u	7.37	3.50	6.70	2.71
NHR	a	.11	.16	.03	.06
	i	.09	.19	.01	.01
	u	.01	.02	.00	.00
HNR	a	14.37	6.15	18.77	3.00
	i	16.49	6.49	18.55	3.78

	u	21.83	4.51	24.22	2.96
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The mean value of F_0 during the phonation of /a/, /i/ and /u/ were found to be not significant when comparing between individuals with PD and normals. However, the mean values were found to be less in individuals with PD than that of the values obtained in normal individuals.

The statistical analysis was carried out using MANOVA to compare the mean value of Jloc between the individuals with PD and normals. The mean value of Jloc between the individuals with PD and normals was found to be of significant difference $F(1, 18) = 4.403$ for phonation of /a/ sound. The values obtained for Jloc were more in individuals with PD than that of the values obtained in normal individuals. Similarly, values of Jloc during phonation of /i/ and /u/ were more in individuals with PD than in normals. These values were also found to be statistically significant $F(1, 18) = 4.462$, and $F(1, 18) = 8.299$ for /i/ and /u/ respectively.

On comparison of mean value of jitter absolute (Jabs) between individuals with PD and normals were found to be statistically non significant for /a/. However, the mean values were found to be more in individuals with PD than that of the values obtained in normal individuals. Similarly, the values obtained for Jabs was greater during phonation of /i/ in individuals with PD than normals. The MANOVA results indicated that these values were found to be statistically significant $F(1, 18) = 4.096$ between the groups. Then the mean values of Jabs between individuals with PD and normals for /u/ were compared, result indicated that there were no significant difference. However, Jabs mean values were higher in individuals with PD than normals.

The mean value of Jrap for phonation /a/ was more in individuals with PD than that of the values obtained in normal individuals. These values were found to be statistically significant $F(1, 18) = 4.594$, $p < 0.05$ between individuals with PD and normal individuals. Similarly, the mean Jrap values found to be significant difference $F(1, 18) = 4.131$ and $F(1, 18) = 8.798$ for /i/ and /u/ respectively.

The mean value of Jppq5 between the individuals with PD and normals were found to be statistically non significant for /a/. However, values obtained were more in individuals with PD than that of the normal individuals. For /i/, statistical findings reports a significant difference $F(1, 18) = 5.281$ for Jppq5 between the individuals with PD and normals after carrying out MANOVA. Similar findings were found $F(1, 18) = 8.874$ for /u/ between individuals with PD and normals. However, mean value of Jppq5 were more in individuals with PD than normals.

The mean values of Jddp were compared using MANOVA and results were found to be significant difference $F(1, 18) = 4.812$ and $F(1, 18) = 8.141$ between individuals with PD and normals for /a/ and /u/ respectively. Whereas no significant difference found for /i/ when Jddp mean values were compared between individuals with PD and normals.

The mean value of Shimmer local (Sloc) for /a/ were found to be significant difference $F(1, 18) = 4.101$ between individuals with PD and normals. However, there were no significant difference between individuals with PD and normals for /i/ and /u/. Among the shimmer parameters, Shimmer (dB) for /a/ shown statistically significant difference $F(1, 18) = 4.140$ while comparing the mean values between the groups. The mean value obtained during the production of /a/ was more in individuals with PD than that of the values obtained in normal individuals. However, Shimmer (dB) values for /i/ and /u/ were found to be statistically not significant. Similarly, the mean value of Sapq3 for /a/ were found to be statistically significant $F(1, 18) = 4.481$ between individuals with PD and normals whereas no significant difference found for /i/ and /u/. However, the mean values of Sapq5, and Sapq11 were found to be statistically non significant for /a/, /i/, and /u/ between individuals with PD and normals.

Shimmer dda (Sdda) values for /a/ were found to be statistically significant $F(1,18) = 4.460$ between the individuals with PD and normals whereas there were no significant difference found for /i/ and /u/. However, the Sdda mean values were more in individuals with PD as compared to that of normal individuals for /a/, /i/, and /u/.

The mean values of Noise to Harmonic Ratio (NHR) were found to be statistically non significant for /a/, /i/, and /u/. However, NHR mean values were slightly higher in individuals with PD than that of normal individuals.

On the other hand, Harmonics to Noise Ratio (HNR) was found to be significant difference $F(1, 18) = 4.114$ between individuals with PD and normals for /a/. However, there were no significant difference noticed for /i/ and /u/. On comparison of mean value of HNR for /i/ and /u/ between normals and individuals with PD, lesser values were found in individuals with PD than that of the values obtained in normal individuals.

In short, jitter and shimmer parameters were observed to be significantly higher in individuals with PD than normals for /a/, /i/, and /u/.

Discussion

The task used in the present study was phonation of vowels /a/, /i/, and /u/. Researchers have widely preferred this task to examine phonatory stability in individuals with PD. The reason for choosing this task was to avoid intrusion from speech prosody and articulation (Baken & Orlikoff, 1992).

The present study results indicate a reduced F0 value in individuals with PD as compared to that of the normal individuals. This could be mainly due to mild severity of PD. Studies reported variation in F0 in individuals with PD due to reduced efficiency of laryngeal muscles. In a study done by Doyle, Raade, St. Pierre, & Desai, (1995), an increase in F0 range and variation was observed during vowel phonation task. The jitter and shimmer parameters were affected in individuals with PD. This may be due to presence of changes in laryngeal function. Favre, Burchiel, Taha, & Hammerstad, (2000) stated that the changes in voice among individuals with PD may be the effect of the size of the lesion as well as of different neurophysiologic and neuroanatomical mechanisms responsible for sensory-motor organization of voice. The feature of occurrence of hypokinesia and bradykinesia in individuals with PD is due to the presence of changes in laryngeal function among these individuals (Baker, Ramig, Luschei, & Smith, 1998).

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Conclusion

The acoustic parameters of voice have been the focus of research related to voice abnormalities. It thus serves as an objective evaluation to support the perceptual findings regarding voice of an individual. However, there have been variations in acoustic parameters within a group of normal individuals itself. Hence, it can be concluded that the acoustic parameters reflects variations in laryngeal area which varies from one to another individual. The reduced muscle tone in laryngeal area of individuals with PD will also be reflected in acoustic parameters.

Thus, in the present study two groups of individuals were included for comparing acoustic parameters related to frequency and amplitude. Individuals with PD were having normal and mild degree of impairment. This was observed to be having more variation in frequency parameters than intensity parameters. This was indicated through higher values obtained in jitter parameters. A higher value of jitter parameters in individuals with PD indicates greater voice fluctuations. However, shimmer parameters were less varied in individuals with PD.

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