

# Acoustic and hearing-perceptual voice analysis in individuals with idiopathic Parkinson's disease in "on" and "off" stages

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## ABSTRACT

**Objective:** To evaluate the voice quality of patients with idiopathic Parkinson's disease, at the "on" and "off" moments of the disease. **Method:** Five individuals with Parkinson's disease and five of the control group were assessed. All of them underwent the recording of voice and speech. The acoustic parameters analyzed were: fundamental frequency, jitter, shimmer, harmonic noise proportion and index of tremor, besides performing the hearing-perceptual analysis by means of GRBASI scale. The findings were analyzed using statistics through t test and the level of significance adopted was  $p < 0.05$ . **Results:** There was no difference in the acoustic parameters in the three analyzed groups. In the hearing-perceptual analysis, patients with idiopathic Parkinson's disease showed altered voice quality and the ones from the control group, neutral vocal quality. **Conclusion:** Patients with idiopathic Parkinson's disease present rough, breathy and unstable vocal quality in both stages. In the acoustic analysis, there are no differences in the studied parameters. **Key words:** Parkinson's disease, voice, speech acoustics, hearing perception.

## Análise acústica e perceptivo-auditiva da voz em indivíduos com doença de Parkinson idiopática nos estágios "on" e "off"

## RESUMO

**Objetivo:** Avaliar a qualidade vocal de pacientes portadores da doença de Parkinson idiopática, nos momentos "on" e "off" da doença. **Método:** Foram avaliados 5 indivíduos com doença de Parkinson idiopática e 5 do grupo controle. Todos foram submetidos à gravação da voz e fala. Os parâmetros acústicos analisados foram: frequência fundamental, jitter, shimmer, PHR e índice de tremor, além da realização da análise perceptivo-auditiva por meio da escala GRBASI. Os achados foram analisados pelo teste t e o nível de significância adotado foi  $p < 0,05$ . **Resultados:** Não foi encontrada diferença nos parâmetros acústicos nos três grupos estudados. Na análise perceptivo-auditiva, os pacientes com doença de Parkinson idiopática apresentaram qualidade vocal alterada e os do grupo controle qualidade vocal neutra. **Conclusão:** Os indivíduos com doença de Parkinson idiopática apresentam qualidade vocal rugosa, soprosa e instável, em ambos estágios. Na análise acústica, não há diferenças nos parâmetros estudados.

**Palavras-chave:** doença de Parkinson, voz, acústica da fala, percepção auditiva.

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Parkinson's disease (PD) can be defined as a neurodegenerative disorder mainly characterized by the degradation of dopaminergic neurons of the basal ganglia, often associated with other etiologies<sup>1</sup>. The combination of two or more clinical symptoms (among them, tremor, rigidity, slowness, reduction or loss of movement and postural changes), along with low concentration of dopamine in the basal ganglia, is the parkinsonism<sup>2</sup>.

Due to the disorder in this neuromuscular control in individuals with Parkinson's disease, the alterations that may affect oral communication are noted, due to lack of coordination of muscle movements that control the responsible organs for speech, causing vocal and articulation disorders and swallowing difficulties, which interfere negatively in communicative expression. Studies describe that vocal alterations, such as imprecise articulation, decreased speech speed, reduced vocal intensity and lower variation of fundamental frequency, are commonly alterations presented by people suffering from Parkinson<sup>3</sup>. According to scholars, the entire phonatory mechanism will be affected in Parkinson's disease, as neuromuscular functions are necessary for the production of an intelligible speech<sup>4</sup>.

Other alterations that may be associated with Parkinson's disease are autonomic disorders. Some examples are: cardiovascular and pupillary changes, gastrointestinal and kidney changes, and appetite and mood alterations<sup>5</sup>.

Among the therapeutic strategies used for the treatment of the disease, symptomatic therapy aims to reduce the signs and symptoms of Parkinsonism. The drug most commonly used today is levodopa, an aromatic amino acid that is converted to dopamine in the central nervous system. When the patient is under the influence of the drug ("on" stage), the symptoms disappear or reduce noticeably, and they reappear after ceasing the action of levodopa ("off" stage).

Despite the advantages brought by the drug, patients with Parkinson's disease and using levodopa tend to develop, after some time, a series of motor complications - such as fluctuations and dyskinesias - and non-motor complications such as gastrointestinal and sleeping disorders<sup>6</sup>. During treatment, the motor fluctuations become more and more abrupt and at random, culminating in the "on-off effect", defined as sudden and unpredictable fluctuations in rates of motor deficiencies, not related to the time of levodopa ingestion<sup>7</sup>. It is estimated that after five years of levodopa use around about 50% of patients will have fluctuations, while 30% have hyperkinesias in addition, most of the time coinciding with the peak of the medication effect (levodopa-induced dyskinesias)<sup>8</sup>.

To study the likely vocal alterations present in individuals with Parkinson's disease, a speech assessment is essential because it is considered an effective tool for the

analysis of voice disorders. Currently there are two forms of voice assessment: a hearing-perceptual analysis of vocal quality and acoustic analysis of the voice.

The hearing-perceptual assessment is the classical evaluation of voice quality, sovereign and traditional in clinical practice. It is a subjective test based especially in the impression of the speech therapist about the voice. Through the hearing impression about the voice, the appraiser classifies the voice quality of the individual as appropriate (neutral) or changed (rough, breathy, whispered, tense, asthenic etc.). There are a number of scales for the hearing assessing the voice, through the use of various tasks for the assessment of the vocal quality<sup>9</sup>.

The acoustic analysis, in turn, is a complementary tool that allows a more objective assessment of the human voice. Through this analysis it is possible to obtain concrete values of acoustic characteristics of the voice, as the fundamental frequency, perturbation measures, as *jitter* and *shimmer*, noise measurements and the obtaining of a sound wave trace. In clinical practice, the acoustic analysis acts mainly as an auxiliary tool of the hearing perceptual assessment, in order to increase the diagnostic accuracy of vocal alterations<sup>9</sup>.

The purpose of this study was to evaluate the voice of patients with idiopathic Parkinson's disease diagnosis at the "on" and "off" moments, objectively and subjectively, by means of acoustic and hearing perceptual analysis.

## METHOD

This is an experimental longitudinal study conducted with two groups paired by sex and age. The experimental group consisted of five patients with idiopathic Parkinson's disease, recruited from the Outpatient Clinic for Movement Disorders of the Neurology Hospital Bias Fortes, UFMG. They were three males (aged between 58 and 72 years, mean of 63.6 years) and two females (aged between 48 and 72 years, mean of 60 years) and duration of the disease from 1 to 18 years, with an average of 8 years. According to the Hoehn-Yahr Scale, four patients were on the scale 2 and one patient on the scale 3 of the development of Parkinson's disease.

The control group was composed of five individuals without neurological disorders, three males (aged from 54 to 71 years, mean of 58.6 years) and two females (aged from 54 to 65 years, mean of 59.5 years).

The criteria for diagnosis of the disease were the Brain Bank of the UK Parkinson's Disease Society Brain Bank Clinical Diagnostic Criteria ones, through clinical neurological assessment at the clinic where patients were recruited. Besides being carriers of the disease, the individuals of the experimental group should be literate, have complete dentition or use dental prosthesis and adequate visual acuity to allow the reading, should not have a his-

tory of laryngeal surgery or alteration and do not present another neurological disease.

The criteria for inclusion of individuals selected for the control group were to be literate and able to read, have complete dentition or use dental prosthesis, have adequate visual acuity to allow the reading, do not have a history of laryngeal surgery or alteration and do not present another neurological disease.

Participants signed a free and clear consent form and were informed about the voluntary and confidential character of the research.

The voices of the individuals were recorded in an acoustically treated booth belonging to the Department of Speech Therapy of São Geraldo Hospital, in a Dell® computer, model Optiplex GX260, with Direct Sound® professional sound board. The acoustic analysis software used was the CSL, MDVP Kay Elemetrics MDVP® module. Professional condenser unidirectional Shure® microphone was used, installed on a pedestal, laterally positioned at a distance of 5 cm from the mouth of the informants, who remained standing during the recording.

The control group was subjected to a voice recording on a unique moment, while the group of informants with idiopathic Parkinson's disease was submitted for recording in two moments: initially after the abstention of levodopa for a period of 12 hours ("off" stage) and then after a period of 30 minutes to 1 hour of levodopa administration ("on" stage). Thus, three groups were analyzed: control group (CG), the experimental group in "off" stage (EG1) and the experimental group in "on" stage (EG2). All people performed the recording of voice and speech through the prolonged vowel /a/ and the reading of a text.

The voice samples were analyzed in a hearing-perceptual way by three speech therapists, voice specialists, using the GRBASI scale. The GRBASI scale aims at the dysphonia global assessment (G-Grade) by identifying the following factors: roughness (R), breathness (B-breathness), asthenia (A) and strain (S-strain)<sup>10,11</sup>. The instability factor (I) was added to the scale later<sup>10</sup>. For these aspects the grade 0 (absent), 1 (mild), 2 (moderate) and 3 (severe) can be assigned. The GRBASI scale is the most used protocol of the hearing-perceptual analysis in clinical practice.

To perform the acoustic analysis, the sustained vowel /a/ was transferred and analyzed by the acoustic analysis software. The investigated parameters in the acoustic analysis were: fundamental frequency (F<sub>0</sub>), which corresponds to the number of vibration cycles per time unit; *jitter* (%): an index of fundamental frequency variability in the short term; *shimmer* (%): an index of variability of the sound wave amplitude in the short-term; noise to harmonic noise proportion (HNP), which computes the noise in a series of pulses produced by the oscillation of

the vocal folds; voice turbulence index (VTI): calculates the energy level of high frequency noise.

The statistical analysis used was the T test and the adopted level of significance was p<0.05.

This work was reviewed by the Research Ethics Committee of the Federal University of Minas Gerais and approved on the report number ETIC 676/07.

## RESULTS

The mean values of acoustic parameters for each group studied were obtained. It is observed that the fundamental frequency (F<sub>0</sub>) presented higher values for both experimental groups (EG1 and EG2), compared to the control group (CG), and even higher for individuals with Parkinson's disease in "on" stage (GE2); the parameter *shimmer* (%) was higher for the group of individuals in "off" stage (GE1) and smaller for the ones in "off" stage; *jitter* (%) had also elevated values for individuals in the group with Parkinson's disease in "off" stage and reduced in "on" stage; the HNP and VTI parameters showed higher values for the control group individuals, and lower for the "on" and "off" experimental groups, respectively.

Table 1 sets out the following results.

After obtaining the average values of each acoustic parameter, the values of significance were calculated for the acoustic measures comparing the three studied groups. There was no statistically significant difference for the analyzed acoustic parameters among the three groups.

Table 2 presents the values of significance that were found.

**Table 1.** Average values of the acoustic parameters in the three studied groups.

	F <sub>0</sub> (Hz)	Shim (%)	Jitt (%)	HNP	VTI
GC	144.34	4.80	1.50	0.20	0.73
GE1	187.30	8.53	1.95	0.19	0.04
GE2	203.07	3.07	0.62	0.13	0.05

GC: group control; GE1: experimental group in the stage on; GE2: experimental group in the off stage; F<sub>0</sub>: fundamental frequency in Hz; *Shim* (%): *shimmer* (vibration amplitude variation cycle by cycle); *Jitt* (%): *jitter* (vibration frequency variation cycle by cycle); HNP: harmonic-noise proportion; VTI: index of vocal turbulence.

**Table 2.** Values of significance for the acoustic measures comparing the three studied groups.

	F <sub>0</sub> (Hz)	Shim (%)	Jitt (%)	HNP	VTI
GC-GE1	0.26	0.26	0.76	0.92	0.14
GC-GE2	0.20	0.25	0.35	0.12	0.31
GE1-GE2	0.07	0.07	0.17	0.68	0.26

GC: group control; GE1: experimental group in the stage on; GE2: experimental group in the off stage; F<sub>0</sub>: fundamental frequency in Hz; *Shim* (%): *shimmer* (vibration amplitude variation cycle by cycle); *Jitt* (%): *jitter* (vibration frequency variation cycle by cycle); HNP: harmonic-noise proportion; VTI: index of vocal turbulence. \*p-value <0.05=statistically significant.

**Table 3.** Values of the hearing-perceptual analysis in the three studied groups.

		G			R			B			A			S			I		
		0	1	2	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
GC	N	5	-	-	4	-	-	5	-	-	5	-	-	5	-	-	5	-	-
	%	100	-	-	80	-	-	100	-	-	100	-	-	100	-	-	100	-	-
GE 1	N	-	2	3	2	1	2	1	2	2	2	-	3	4	-	1	4	-	-
	%	-	40	60	40	20	40	20	40	40	40	-	60	80	-	20	80	-	20
GE 2	N	-	1	4	1	-	4	1	3	1	2	-	3	5	-	-	1	3	1
	%	-	20	80	2	-	80	20	60	20	40	-	60	100	-	-	20	60	20

GC: group control; GE1: experimental group in the stage on; GE2: experimental group in the off stage; N: number of individuals; G: dysphonia global assessment; R: roughness; B: breathness; A: asthenia; S: strain; I: instability factor.

After the hearing-perceptual assessment, values for each parameter of the GRBASI scale, in the three groups, were extracted. It was found that 100% of the individuals in the control group present neutral vocal quality, 60% of individuals in the "off" stage of the disease have moderate dysphonia and 40% had mild dysphonia; 80% of individuals in the "on" stage of the disease present moderate dysphonia and 20% a mild one.

Table 3 sets out the values assigned to the voices of each group, analyzed in a hearing-perceptual way through GRBASI scale.

## DISCUSSION

The acoustic and hearing-perceptual analysis used for vocal assessment of the individuals who composed the study sample enabled the verification of the vocal features of the experimental and control groups, with subsequent comparison among the obtained values.

Although higher values for acoustic parameters of fundamental frequency ( $F_0$ ) were identified, *shimmer* (%) and *jitter* (%) and lower values for HNP and VTI in the experimental groups ("on" and "off" stages), the study in question did not show statistically significant difference for any of these parameters when compared with the three studied groups (Tables 1 and 2). The results of this study agree in part with the researched literature and, during their interpretation, one should consider the methodological differences, especially regarding the quantity of sample used in the studies that were found and the acoustic analysis software which was used.

Scholars held voice acoustic analysis of 20 patients with Parkinson's disease in the "on" and "off" stages of the disease, in comparison with a control group, and identified a significant increase of fundamental frequency in the "on" stage and a also significant reduction in the *jitter*, HNP and VTI values, after medication<sup>12</sup>, unlike the results from our study, whose  $F_0$  value, despite increased for the "on" stage group, was not significantly higher, and the *jitter*, HNP and VTI values were not significantly reduced in the group in the "on" stage (Table 2). Possibly the

difference in the results is due to the significantly smaller sample in this study, besides the methodological differences of the type of extraction of acoustic parameters.

In a study that quantified the acoustic measures of voice and speech of 41 patients with Parkinson's disease under drug treatment ("on" stage), compared with a control group paired by sex and age, the groups with Parkinson's disease showed increased measures of  $F_0$  and *jitter* and reducing of vocal intensity, of the HNP values and of the variability of frequency and intensity in relation to the group control<sup>13</sup>. Our results agree with the literature in relation to the values of  $F_0$ , which were elevated in groups with Parkinson's disease in the "on" stage. However, there was disagreement in relation to the values of *jitter*, which in this study showed reduced values on the "on" group compared with the control group (Table 1). Nevertheless, these values were not statistically significant (Table 2).

In a study evaluating the voice and speech of patients with Parkinson's disease before and after pallidotomy in the "on" and "off" stages of the disease, by means of acoustic analysis, it was not found a statistically significant difference among the values of  $F_0$ , *jitter*, *shimmer*, PPQ (pitch perturbation quotient), APQ (amplitude perturbation quotient) and NHR (noise-harmonic ratio), pre- and post-pallidotomy, both in the "on" and "off" stages of the disease. However, except for the  $F_0$ , which increased with drug intake, other values were reduced during the "on" stage before and after the surgery<sup>14</sup>. Considering that pallidotomy did not interfere significantly in the acoustic measurements analyzed and that the differences found are due to the drugs, the results agree with this study, which found increased values for  $F_0$  and reduced values for *jitter*, *shimmer* and HNP in the "on" stage of the disease.

In order to identify changes in the values of fundamental frequency in the "on" and "off" stages of Parkinson's disease, a study analyzed the speech of patients immediately before and immediately after the producing of a consonant and found increased values of  $F_0$  for individuals in the "on" stage. The study linked the increase of  $F_0$  to an increase in tension caused by the use of the antiparkinsonian

drug<sup>15</sup>. The present study found  $F_0$  values extracted from the sustained vowel /a/, increased for both experimental groups, especially for the group in the "on" stage. However, there is no statistically significant difference when compared to the control group and the "off" stage group (Tables 1 and 2). The discrepant results may be justified by the methodological difference between the two surveys.

A survey on the hearing-perceptual and acoustic analysis in neurological dysphonias revealed that in all the types of dysarthrias, including the hypokinetic dysarthria present in patients with idiopathic Parkinson's disease, the *jitter* and *shimmer* measures are altered and elevated<sup>16</sup>. In agreement with these results, Table 1 of our study describes an increase of the same measures for the group in the "off" stage of the disease.

A study examined the effect of levodopa on the speech of patients with Parkinson's disease. It was observed that the drug effect on the acoustic features of the speech will depend on the profile of the individual's speech at the time of assessment, as levodopa promotes articulation, sound, rhythm, vocal amplitude and speech intelligibility of speech in a general form<sup>17</sup>.

As for the hearing-perceptual evaluations carried out by GRBASI scale and described in Table 3, changes in vocal quality for all patients with Parkinson's disease were observed, showing, preferably, rough, breathy and unstable voices. These hearing-perceptual features are usually associated with hypokinesia and rigidity of the muscles involved in respiration, phonation and articulação<sup>18,19</sup>. The incomplete glottic closing prevents the increase of subglottic pressure and justifies the perception of a breathy voice<sup>20</sup>.

The literature is in favor of the results found in this research. Experts say that the altered voice quality is commonly found in patients with Parkinson's disease assessed in a hearing-perceptual form<sup>14</sup>.

Studies classify the voice quality of individuals with Parkinson's disease as hoarse-harsh-breathy, with the presence of phonation instability<sup>20-22</sup>. In this study, most of the voices in the experimental groups were classified as rough, breathy and unstable, while the neutral vocal quality was predominant in the group without Parkinson's disease. These results are consistent with the data found in the literature and are described in Table 3.

A study conducted the survey of vocal complaints of 118 patients with Parkinson's disease, with subsequent hearing-perceptual assessment of the voices, through GRBASI scale and the vocal attack. Weak voice was the most frequent complaint, which justifies the mild to moderate degree of deviation of the "asthenia" parameter, obtained in the hearing-perceptual analysis. The vocal instability was as diverted as the asthenia, which gives the negative impact of a deteriorated speech<sup>19</sup>. In this study, the "asthe-

nia" and "instability" parameters are present in most patients with Parkinson's disease, both in the "on" and "off" stages (Table 3).

In order to evaluate the effect of levodopa on respiration and speech intelligibility of patients with Parkinson's disease, 25 patients were assessed using a dysarthria protocol. It was found that both respiratory standard and speech intelligibility improved with the drug. However it can not be stated that these results are related to an improvement in vocal quality of these individuals. Thus, the study ponders over the need for research that assesses the changes of vocal characteristics of individuals with Parkinson's disease under levodopa treatment<sup>23</sup>. This study found no statistically significant differences in vocal quality of individuals with neurological disease under dopaminergic medication, as it is represented in Table 3.

Considering the findings of this study and all the researched literature, one sees that the effect of levodopa does not carry out significantly improvement in the voice patterns of the patient with Parkinson's disease, objectively and subjectively assessed.

The literature identifies and describes several advantages brought by the administration of levodopa, which especially promotes an increase of life quality of patients under medication treatment. Among the benefits of the drug, it can be highlighted: better performance of muscular behavior, increase of the activities of the olfactory and blood system, increase of cognition, memory capacity and attention, and reduction of the depression and anxiety<sup>24-30</sup>.

Future research should be necessary with a more significant sample to better understand the behavior of the acoustic hearing-perceptual parameters of the voice in individuals with Parkinson disease.

The conclusions from the study in question are: there are no statistically significant difference among the acoustic parameters of fundamental frequency, *jitter*, *shimmer*, VTI and HNP of the groups with Parkinson's disease in "off" and "on" stages and the control group. Patients with idiopathic Parkinson's disease present altered vocal quality classified as rough, breathy and unstable, from mild to moderate degrees. Medical therapy with levodopa does not interfere significantly in the vocal patterns of patients with Parkinson's disease when compared to the "on" and "off" stages.

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