Relationship Between Voice and Motor Disabilities of Parkinson's Disease

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Summary: To evaluate voice of Iranian patients with Parkinson's disease (PD) and find any relationship between motor disabilities and acoustic voice parameters as speech motor components. We evaluated 27 Farsi-speaking PD patients and 21 age- and sex-matched healthy persons as control. Motor performance was assessed by the Unified Parkinson's Disease Rating Scale part III and Hoehn and Yahr rating scale in the "on" state. Acoustic voice evaluation, including fundamental frequency (f0), standard deviation of f0, minimum of f0, maximum of f0, shimmer, jitter, and harmonic to noise ratio, was done using the *Praat* software via /a/ prolongation. No difference was seen between the voice of the patients and the voice of the controls. f0 and its variation had a significant correlation with the duration of the disease, but did not have any relationships with the Unified Parkinson's Disease Rating Scale part III. Only limited relationship was observed between voice and motor disabilities. Tremor is an important main feature of PD that affects motor and phonation systems. Females had an older age at onset, more prolonged disease, and more severe motor disabilities (not statistically significant), but phonation disorders were more frequent in males and showed more relationship with severity of motor disabilities. Voice is affected by PD earlier than many other motor components and is more sensitive to disease progression. Tremor is the most effective part of PD that impacts voice. PD has more effect on voice of male *versus* female patients.

Key Words: Parkinson's disease–motor disorders–UPDRS–voice–acoustic.

INTRODUCTION

Idiopathic Parkinson's disease (IPD) is a neurodegenerative disorder with motor and nonmotor clinical manifestations. Bradykinesia, rigidity, tremor at rest, and postural instability constitute core motor features,[1] whereas neuropsychiatric disorders, autonomic dysfunction, and sleep difficulties are common nonmotor symptoms.[2] Speech abnormality is a very common motor disorder in IPD. Hypokinetic dysarthria, a speech alteration that affects all speech subsystems such as respiration, phonation, articulation, and prosody,[3] is observed in almost 90% of the IPD patients.[4,5] It seems that voice is affected earlier in this process followed by articulation and fluency abnormalities.[6] Most distinct and frequent voice symptoms of PD are mono loudness, mono pitch, breathiness, harshness, and reduced loudness.[7] It is believed that perceptual features of hypokinetic dysarthria are related to pathophysiological motor deficits; for instance, mono loudness, mono pitch, variable rate, short rushes of speech, and reduced stress are in accordance with muscle rigidity,[8] and long and excessive pauses may result from bradykinesia.[9] In recent decades, some studies used the Unified Parkinson's Disease Rating Scale part III (UPDRS-III) to investigate any relationship between the IPD motor severity and the patients' voice characteristics. Whereas some studies have reported a strong relationship between UPDRS-III and acoustic voice parameters,[10–13] others have declined such a relationship.[14–17] A limited number of surveys were conducted to find a connection between voice and motor disabilities (UPDRS-III subscales) in PD patients.[15,18] The authors of these surveys tried to figure out whether the speech is a peripheral or an axial feature of PD and also to figure out what is the effect of dopaminergic medication therapy on speech. Because the authors studied small groups of patients,[18] and patients were in early stages of the disease,[15] their results are questionable.

As the disease progresses, deterioration of motor and nonmotor features is expected.[6,19] There has been a debate about the relationship between IPD duration and speech and voice characteristics. Some studies suggested the negative effect of disease duration on speech parameters,[20–22] whereas others detected no relationship between those factors.[14,16,17,23]

Because previous studies reported contradictory results and there is no survey on Farsi-speaking Iranian IPD patients, this study focused on the impact of disease duration and severity on the phonation features, and compared the vocal characteristics of patients with a normal group to find any changes resulting from PD in Farsi-speaking patients. In addition, the present study tried to answer the question whether the phonation system (voice) has a separate mechanism from other motor mechanisms in IPD.

MATERIALS AND METHODS

The study protocol was approved by the Ethics Committee of Tehran University of Medical Sciences. Informed consent was obtained from all study participants. This cross-sectional, nonexperimental study was carried out on 27 IPD patients and 21 healthy age- and sex-matched control subjects (Table 1). The patients were recruited by convenience sampling from the movement disorders clinic of Rasool-e-Akram Hospital, Iran University of Medical Sciences, and a private movement disorders clinic run by one of the authors (G.S.). The diagnosis of IPD was based on the UK Parkinson's Disease Society Brain Bank's clinical

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TABLE 1.
Basic Characteristics of PD Patients

Sex	Number	Age (Mean ± SD)	PD Severity (UPDRS-III) Min	Max	(Mean ± SD)	Severity (H&Y) Min	Max	(Mean ± SD)	Duration of Disease (Mean ± SD)
Male	15	61.6 ± 8.94	13	62	29.60 ± 14.237	2	3	2.07 ± 0.258	8.6 ± 4.5
Female	12	59.33 ± 7.3	11	84	35.42 ± 19.88	1	3	2.25 ± 0.622	11.41 ± 7.66
Total	27	60.59 ± 8.18	11	84	32.19 ± 16.88	1	3	2.15 ± 0.456	9.85 ± 6.15

Notes: The units of age and duration of disease: Year. Month (61.6 means 61 years and 6 months).
Abbreviations: H&Y, Hoehn and Yahr; max, maximum; min, minimum; PD, Parkinson's disease; SD, standard deviation; UPDRS-III, third part of the Unified Parkinson's Disease Rating Scale.

diagnostic criteria.[2] Inclusion criteria of this study were (1) no other neurological or movement disorders, (2) ages above 50 years, (3) at least 3 months of levodopa therapy, (4) disease duration more than 5 years, (5) no history of speech therapy, (6) being monolingual (only Farsi speakers), (7) no history of laryngeal cancer and endotracheal intubation, and (8) no history of surgery, chemotherapy, radiotherapy, or trauma to the head and neck. All participants had used levodopa as the main drug. Amantadine, dopamine agonists, benzodiazepines, and selective serotonin reuptake inhibitors were among the medications taken by participants. All healthy subjects were checked by a neurologist (S.K.) and an otolaryngologist for any neurological or voice disorder, respectively.

The disease severity was assessed by two sets of tests: UPDRS-III (score 0–132) and Hoehn & Yahr rating scale (H&Y; score 1–5). All participants were examined 45–90 minutes after taking their regular dose of levodopa-carbidopa, so they were in the "on" state during rating. After both ratings were completed, a speech and language pathologist (F.M.), not blinded to the study, assessed and recorded the subjects' voice in a quiet room (noise less than 35 dB).[20] The participants sat on a fixed armchair with a headset (Sony DR-320DPV, Japan) placed on their ears, and the microphone-to-mouth distance was 8 cm.[8] After being instructed by the examiner, all participants were asked to prolong the vowel /a/ (with their habitual pitch and loudness) two times, each time for 5 seconds (39), and the second sequence was recorded for acoustic parameters analysis. Voice samples were recorded on a laptop (MSI-CR420, China; OS: Windows XP, sound card 6.1.7600.16385, Paul Boersma). In the present study, *Praat* software version 5.1.17 was used to analyze mean fundamental frequency (f0), standard deviation of f0 (f0SD), minimum of f0 (min f0), maximum of f0 (max f0), shimmer, jitter, and harmonic to noise ratio (HNR). Both neurological and speech tests were done at the same center in a single visit.

Statistical analyses

SPSS Statistics 16 software was used for statistical analysis (Sun Microsystems, Inc., Santa Clara, CA, USA). We used the Kolmogorov-Smirnov test to determine the normality of the variables, and the Mann-Whitney *U* test and the independent sample *t* test to compare the mean variables in patient and in control groups. Pearson and Spearman correlation coefficients were used to evaluate any statistically significant relationship between voice features and total UPDRS-III and its subscales. Chi-square test was used to ascertain sex equality. The confidence interval was 95% ($P < 0.05$).

RESULTS

Gender, age, duration of PD, total UPDRS-III, and H&Y scores are shown in Table 1. Almost 65% of the patients were in the first decade of disease, 26% were in the second decade, and 8% were in the third decade. The independent sample *t* test and chi-square test showed that the patients and the controls were age ($P = 0.619$) and sex ($P = 0.585$) matched. The age at onset of the female patients (53 ± 11.25 years) was not different from that of the male patients (47.91 ± 10.29 years) ($P = 0.73$). The difference in the disease duration was not significant between male and female patients ($P = 0.055$). The highest H&Y and UPDRS-III scores were 3 (in both sexes) and 84 (in females), respectively. Although females had higher disease severity than males (84 *vs* 62), the difference was not statistically significant.

Acoustic voice evaluation

Independent sample *t* test was used to compare the mean f0, min f0, max f0, shimmer, and HNR between IPD and control groups, and Mann-Whitney *U* test was used for SDf0. We did not find any significant differences in the acoustic voice characteristics between the two groups before and after sex segregation (Table 2).

Relationship between voice, disease duration, and disease severity

Some variables like f0, max f0, min f0, shimmer, HNR, disease duration, UPDRS-III score, and severity of rigidity and leg agility in UPDRS-III had normal distributions, but other variables did not follow the same pattern. So, to investigate the relationship between voice, disease duration, disease severity, and motor disabilities, a parametric (Pearson correlation coefficient) and a nonparametric correlation test (spearman correlation coefficient) were used.

Table 3 shows the relationship between disease duration, voice characteristics, and disease severity of the patients.

In the IPD group, f0 (r = 0.440), SDf0 (r = 0.397), min f0 (0.448), and max f0 (r = 0.433) had a positive correlation with the disease duration. In female patients, there was a relationship between the duration of PD and f0 (r = 0.599) and shimmer (r = 0.626), but a similar relationship was not found in the male patients. There was no correlation between the PD duration and UPDRS-III (disease severity), but there was a positive