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**Keywords**

Parkinson Disease  
 Rehabilitation  
 Voice  
 Health Services  
 Telemedicine

**Descritores**

Doença de Parkinson  
 Reabilitação  
 Voz  
 Serviços de Saúde  
 Telemedicina

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**Received:** August 06, 2014

**Accepted:** July 07, 2015

# Voice telerehabilitation in Parkinson's disease

## *Telerreabilitação vocal na doença de Parkinson*

**ABSTRACT**

Parkinson's disease (PD) is a neurodegenerative condition associated with motor, neuropsychological, sensorial, and vocal symptoms. It has been suggested that eventual obstacles faced by many patients to reach speech therapy rehabilitation centers could be overcome with the use of synchronous telerehabilitation (real time) approach employing communication technologies. **Purpose:** To investigate the efficacy of vocal telerehabilitation in PD patients. **Methods:** Twenty patients diagnosed with PD and with vocal complaints participated in this study. Patients were evaluated by videoconference (Adobe Connect 8) before and after treatment. Evaluation method consisted of perceptual analysis of vocal quality measured by the GRBASI scale. Treatment was conducted following the extended version of Lee Silverman method (LSVT-X). At the end of treatment all patients were requested to fill a questionnaire to assess their experience with telerehabilitation. **Results:** Analysis revealed decrease in magnitude of voice quality changes after the intervention, indicating improvement of vocal pattern. All patients reported satisfaction and preference for telerehabilitation compared to face-to-face rehabilitation, as well as positive perception of audio and video. Some technological adversities have been identified but did not prevent the approaches to assessment and treatment. **Conclusion:** Present results suggest that telerehabilitation methods can be considered as an effective treatment for speech symptoms associated with PD and can be indicated to patients presenting limited access to speech therapy centers and technological readiness.

**RESUMO**

A doença de Parkinson (DP) é uma moléstia neurodegenerativa associada a significantes prejuízos motores, neuropsicológicos e sensoriais. Alterações na qualidade da voz são frequentes durante o curso da doença e os pacientes enfrentam obstáculos no acesso a serviços de reabilitação fonoaudiológica adequada. A telerreabilitação é uma possível solução para esse problema, uma vez que pode ser implementada a distância, com recursos de telemedicina, via tecnologias de comunicação e informação. **Objetivo:** Investigar a eficiência da telerreabilitação da voz em pacientes com DP. **Métodos:** Participaram 20 pacientes com DP e queixas de voz. A telerreabilitação síncrona (em tempo real) ocorreu a partir de videoconferência (Adobe Connect 8), os pacientes foram telerreabilitados pela versão estendida do Lee Silverman Voice Treatment (LSVT-X) e avaliados, antes e depois dessa intervenção por meio de análise perceptual da qualidade vocal pela Escala GRBASI. No final da intervenção, todos responderam a questionário estruturado sobre a experiência com a telerreabilitação. **Resultados:** As análises revelaram diminuição na magnitude das alterações da qualidade da voz após a intervenção, indicando melhoria do padrão vocal. Todos os pacientes relataram satisfação e preferência pela telerreabilitação em comparação com a reabilitação presencial, assim como positiva percepção de áudio e vídeo. Algumas adversidades tecnológicas foram identificadas, mas não impediram as abordagens de avaliação e tratamento. **Conclusão:** Os resultados sugerem que a telerreabilitação seja uma intervenção eficiente para os sintomas da qualidade da voz associados à DP e pode ser indicada para pacientes com acesso a tecnologias e dificuldades no alcance de profissionais ou centros especializados.

Study carried out at Departamento de Neurologia, Hospital das Clínicas, Faculdade de Medicina, Universidade de São Paulo – USP - São Paulo (SP), Brazil.

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**Financial support:** Fundação de Amparo à Pesquisa do Estado de São Paulo – FAPESP, process no. 11/51667-0.

**Conflict of interests:** nothing to declare.

## INTRODUCTION

Parkinson's disease (PD), also known as idiopathic parkinsonism, is a condition affecting up to two-third of the patients who look for services on Movement Disorders, and is classified as the second most prevalent neurodegenerative disease<sup>(1)</sup>. PD is present in approximately 1% of the population aged more than 65 years<sup>(2)</sup> and the prevalence of the disease has been estimated between 85 and 187 cases per 100,000 people or 0.1% of the overall population<sup>(3)</sup>. In Brazil, the prevalence is of 0.3% of the population, affecting 3.3% of the individuals aged over 65 years<sup>(4)</sup>.

PD is related to loss of dopaminergic neurons in the substantia nigra and to dopamine deficiency in the striatum which results in abnormal activity in the subthalamic nucleus and in the internal segment of the globus pallidus and causes the motor manifestations of the disease<sup>(5)</sup>. These manifestations are characterized by the presence of tremor, bradykinesia, rigidity, and alterations in postural reflexes<sup>(6)</sup>. Although the neural mechanisms underlying vocal symptoms are not clear, the combination of bradykinesia/hypokinesia with psychological and sensory components is pointed out as responsible for voice impairment (dysphonia)<sup>(7)</sup>.

Losses in voice production, which occur along with other speech problems, concern the majority of patients with PD (90%)<sup>(8,9)</sup> and result in the decrease of familiar, social, and professional interactions, as well as in isolation and consequent deterioration of quality of life<sup>(10)</sup>. Perceptually, the quality of voice in PD is characterized by the presence of hoarseness, breathiness, and reduced tension<sup>(7)</sup>.

There is little evidence that pharmacological and surgical treatments or traditional speech language therapy techniques be effective in the rehabilitation of voice in PD. On the other hand, it is recognized that the most efficient approach for the treatment of voice alterations directed to patients with PD is called Lee Silverman Voice Treatment (LSVT or LSVT LOUD)<sup>(11)</sup>.

In its classic form, the LSVT is an intensive care method with duration of one month and consists of 16 sessions four times a week. The method had been reevaluated and modified in order to improve its applicability. In this sense, studies involving new forms of administration revealed similar results to those achieved by the traditional application system<sup>(12)</sup>. The LSVT-X, traditional intensive training program known as expanded, is highlighted, once it consists of 16 sessions spread over eight weeks, taking place twice a week<sup>(13)</sup>.

Despite the promising results obtained from the applications of the method<sup>(11)</sup>, some obstacles are observed in the access of the patients, such as the shortage of specialized services in speech therapy in both public and private health systems, limited availability of speech language therapists trained to conduct the rehabilitation by LSVT<sup>(14)</sup>, and inappropriate geographic distribution of these services and professionals.

Some patients face several obstacles in order to attend to rehabilitation, such as physical disability to travel to the treatment site, long distances to the services, absence/unavailability of an escort, and difficulties with transportation<sup>(14-16)</sup>.

The distance rehabilitation, named telerehabilitation, is carried out through information and communication technologies and may mitigate these problems. Thus, patients may be rehabilitated in their own homes or in nearby places, such as those of friends or family<sup>(17-19)</sup>, with equivalent results to the ones presented in face-to-face rehabilitation<sup>(8,16,17,20)</sup>.

The objective of this study is to investigate the efficiency of vocal telerehabilitation in patients with PD.

## METHODS

### Patients

We studied 20 patients, 17 men and 3 women, aged between 42 and 78 years submitted to the following inclusion criteria: diagnosis of idiopathic Parkinson's Disease (IPD) according to the UK Parkinson's Disease Brain Bank Criteria<sup>(21)</sup>; and the stage of the disease between 2 and 4 by the Modified Hoehn and Yahr Scale (HY Scale)<sup>(22)</sup>, according to their neurologists (not authors of this study); voice complaints; and access to a computer with headset microphone, camera and Internet; with or without proficiency in the use of technologies. Patients with surgery for PD, cognitive decline, concomitant aphasia, and speech therapy were excluded.

They all presented medical report and neurological referrals and signed the informed consent in order to participate in the study.

### Telerehabilitation procedures

Speech therapy telerehabilitation was promoted through the outreach of the community in public and private hospitals, medical offices, associations for PD caregivers, national meetings, social networks, and coverage of both printed and electronic media.

Patients willing to participate requested a consultation via e-mail. For standardization purposes, all consultations and sessions were carried out in previously scheduled date and time. They all received an Internet address through which they requested their login into the virtual room. After instant permission, the interaction would be initiated, and they were all individually submitted to a medical and speech language evaluation. Candidates who met inclusion criteria were given detailed instructions on the telerehabilitation program.

Patients did not necessarily need to own a computer or to master Internet skills and could count on the help of facilitators (friend or family) for technological handling. During all procedures, the speech language therapist remotely controlled the contents displayed on the computer screen used by the patients (activation and adjustment of audio and video), without the need for them to operate the system.

Patients were asked to remain seated in front of the computer, approximately 50 cm from the screen, in order to reduce sound distortion, maximize visibility, and allow recording.

Sound material was captured and edited in order to be presented to the evaluators who carried out the voice analysis. The recording of sounds allowed documenting voice samples, providing the evaluators an instrument by which they could review the material as many times as wanted. The good quality

of sound recordings allowed the detailed observation of voice quality.

### **Telerehabilitation technology**

The synchronous telerehabilitation (in real time) was carried out with a Macbookpro Apple Computer (16GB RAM, HD 500GB, i7) with microphone and camera. The procedures were conducted with a bandwidth Internet connection of 256 Kbps, resolution of 640 × 480 pixels and 20 fps, through the videoconference system developed by the Telemedicine Discipline of the School of Medicine of the University of São Paulo from the Adobe Connect 8 software (Adobe Systems Incorporated), installed in an HP ProLiant DL320 Generation 5 server. The voice samples were recorded in the computer and in the server.

The technology was controlled with password and authentication protection and followed the rules of storing, handling, and transmission of data, ensuring protection, privacy, and confidentiality and secrecy (Federal Council of Speech Language and Audiology Resolution (*Resolução Conselho Federal de Fonoaudiologia*) CFFa 366).

### **Distance procedures**

#### *Neurological analysis*

Neurologists specialized in movement disorders and also authors of this study examined for clinical signs and confirmation of the PD during the active phase of the medication for PD symptoms (“on phase”). The analysis occurred before beginning of voice treatment. Sessions had 30 to 60 minutes duration and consisted of researching the history of the disease and remote neurological test, which included components of the H-Y Scale, such as the analysis of tremors at rest, tremor during action, finger tapping, hand movements, and rising from the chair and gait.

#### *Speech-language pathology evaluation*

Patients were evaluated during the “on” phase one session before (1st) and one session after (18th) the treatment, from the (qualitative) perceptual analysis of voice quality. Each session lasted approximately one hour.

Each patient were asked, individually, to pronounce the isolated and sustained vowel /a/, to count from 1 to 20, and to spontaneously produce speech (monologue) while commenting on their own voices. The samples were recorded by the author speech therapist in audio recordings which were stored into a microcomputer/server and, later on, analyzed by three speech therapists blind as for the form of rehabilitation, moment of evaluation (before and after treatment) and clinical status of the patients. They were all specialists, trained and experienced in voice treatment in PD. Together, the speech therapists judges assessed inter- and intra-evaluators in other researches, in the present study, they listened to the voice samples together presented randomly and, in a consensus, analyzed and determined the characteristics of the voice quality of the patients according to the GRBASI scale<sup>(23)</sup>, which has a script well known by the group.

The scale aims at the overall assessment of dysphonia (G = grade), through the identification of the following qualities of the voice: hoarseness (R = rough), breathiness (B = breath), asthenia (A = asthenic), tension (S = strain), and instability (I = instability). A four-point scale was used in order to identify the degree of deviation of each one of the qualities, in which 0 meant “no alteration”; 1, “slight alteration”; 2, “moderate alteration”; and 3, “marked alteration.”

#### *Speech-language pathology rehabilitation*

Patients during “on” phase were submitted to the Lee Silverman Voice Treatment in its extended version (LSVT-X) by the speech language therapist and author of this study, a professional trained and certificated for applying the method. The treatment program consisted of 16 sessions, distributed over eight weeks, performed twice a week<sup>(13)</sup>. Each session, from the 2nd to the 17th, lasted approximately one hour.

#### *Satisfaction questionnaire*

In order to obtain subjective impressions from each patient about telerehabilitation, they all answered a structured questionnaire at the end of the procedures, based on a similar study previously published<sup>(16)</sup>. In a scale of five points, the questionnaire evaluated the satisfaction of patients from the answers to four questions: 1. to like or not to like the telerehabilitation and the preference for distance or face-to-face rehabilitation; 2. to evaluate the overall satisfaction with telerehabilitation (answers from very satisfied to very dissatisfied); 3. to evaluate the audio quality during sessions (answers from excellent to bad); and 4, to evaluate the video quality during sessions (answers from excellent to bad). The answers were collected in the last session (18th) and took approximately 10 minutes.

### **Statistics**

The consensus of the analysis of characteristics of voice quality was compared between both telerehabilitation periods by the Wilcoxon test. In order to apply this statistical test, the rejection of the null hypothesis was set at 0.05 ( $\alpha = 5\%$ ).

Descriptive statistics was used in order to evaluate the opinion of patients regarding the telerehabilitation by videoconference and the answers were calculated as for quantities and percentage.

### **Ethics**

This study was approved by the Ethics Committee for Research Project Analysis (*Comissão de Ética para Análise de Projetos de Pesquisa – CAPPesq*) of the Board of the *Hospital das Clínicas* of the School of Medicine of the University of São Paulo under No. 841/11.

### **RESULTS**

Results are shown in Table 1, which reveals significant difference in all voice parameters analyzed.

The voice samples served as a parameter for the analysis of speech-language treatment efficiency by telerehabilitation

LSVT-X, which was executed as a derivation of the favorable audio and sound quality of the technological system. In this plan, the results showed an improvement in voice after treatment. Thus, it is possible to recognize that the telerehabilitation is feasible for the voice treatment in PD.

Table 2 shows the results of patient perception about telerehabilitation. They all approved and reported the preference of telerehabilitation over present rehabilitation. Sixteen (80%) of them reported being very satisfied with telerehabilitation and four (20%) of them reported satisfaction. There was equality in the answers about audio and video quality, nine (45%) of them answered that both were excellent and 11 (55%) that it was adequate.

## DISCUSSION

PD is a movement disorder, which may cause hypokinetic dysarthria and affects several subsystems of speech and voice throughout its evolution.

The voice quality requires the joint action of the larynx and the supralaryngeal vocal tract. Physiological anomalies associated to voice quality disorders in people with PD refer to the functioning of the vocal folds, including reduction of adduction and asymmetric vibration patterns, as well as reduced mobility and amplitude of the lips, cheeks and jaw.

The possibility of interventions capable of optimizing voice quality and improve verbal communication of patients with PD in the distance represents an important alternative for this population,

**Table 1.** Comparison of voice quality in the periods analyzed by the Wilcoxon Test

E S C A L E	BEFORE TELEREHABILITATION								AFTER TELEREHABILITATION								p-value ( $< 0.05$ )
	0		1		2		3		0		1		2		3		
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	
G	0	(0)	2	(10)	8	(40)	10	(50)	0	(0)	13	(65)	7	(35)	0	(0)	<0.001
R	0	(0)	3	(15)	5	(25)	12	(60)	4	(20)	7	(35)	9	(45)	0	(0)	<0.001
B	2	(10)	4	(20)	5	(25)	9	(45)	5	(25)	8	(40)	7	(35)	0	(0)	<0.001
A	0	(0)	3	(15)	8	(40)	9	(45)	6	(30)	4	(20)	4	(20)	6	(30)	<0.001
S	2	(10)	10	(50)	6	(30)	2	(10)	0	(0)	11	(55)	8	(40)	1	(5)	<0.001
I	2	(10)	5	(15)	12	(60)	1	(5)	0	(0)	9	(45)	11	(55)	0	(0)	<0.001

Caption: G = Grid; R = Rough; B = Breath; A = Asthenic; S = Strain; I = Instability; 0 = without alteration; 1 = slight alteration; 2 = Moderate alteration; 3 = Marked alteration

**Table 2.** Answers of patients to the questions about satisfaction with telerehabilitation

Question 1: How did you feel taking part in this treatment?		
Answers:	N	%
a. I liked it, I prefer the Internet treatment, not the face to face one.	20	100
b. I didn't like it, but I prefer the Internet treatment, not the face to face one.	0	0
c. I liked it, but I prefer the face-to-face treatment, not the internet one.	0	0
d. I didn't like it, but I prefer the face to face treatment, not the Internet one.	0	0
Question 2: Evaluate your overall satisfaction to the Internet treatment.		
Answers:	N	%
a. Very satisfied	16	80
b. Satisfied	4	20
c. Dissatisfied	0	0
d. Very dissatisfied	0	0
Question 3: What is your opinion about the quality of the audio (what could you hear) during the sessions?		
Answers:	N	%
a. Excellent	9	45
b. Adequate	11	55
c. Inadequate	0	0
d. Bad	0	0
Question 4: What is your opinion about the quality of the video (what could you see) during the sessions?		
Answers:	N	%
a. Excellent	9	45
b. Adequate	11	55
c. Inadequate	0	0
d. Bad	0	0



since the access to appropriate services for the evaluation and treatment is limited and there is an obvious disparity between offer and demand for speech-language rehabilitation.

In this study, all patients had dysphonia and alterations in voice quality in several degrees. The results revealed that the pattern of voice quality improved as the magnitude of the alterations decreased, after telerehabilitation intervention by the LSVT-X.

These observations were possible from comparisons of the voice quality determined by the evaluators, according to vocal characterizations obtained by perceptual evaluation. This evaluation is essential to the analysis of voice quality, once it provides important information on biological, psychological, educational, and social aspects. For such, the GRBASI Scale is widely used and recognized.

The vocal characteristics analyzed are common among patients with PD, with combined (except asthenia and tension) and isolated occurrence and in various degrees of deviation. Hoarseness is related to the irregularity of vibration in the vocal folds. Breathiness is triggered by spindle chink and bowing of the vocal folds during phonation. Asthenia is the result of weakness of phonatory structures during the production of the voice. The tension is generated by the hyperfunctional state of the phonatory apparatus. Instability is associated to fluctuations in pitch and/or voice quality.

These vocal characteristics may be attributed to muscle, tissue, and respiratory system modifications resulting from bradykinesia/hypokinesia and rigidity. However, the comprehension of neurophysiology regarding dopamine loss and their potential impact on voice may be only a partial explanation, once recent researches suggest that non-dopaminergic neurons are also involved, as well as the participation of sensory losses in the monitoring and maintenance of the amplitude of movements of all mechanism of voice production<sup>(11)</sup>.

The utilization of the technological system was enough so that the evaluators could determine the presence and the degree of voice deviation stored at a distance. These findings suggest that the application of telerehabilitation based on videoconference is a valid tool for the perceptual evaluation of the voice in PD.

The treatment itself was carried out successfully and the technology employed was controlled independently of any intervention by the patients. This study was designed with strict observance of the guidelines of user interface in order to maximize the ease of use, the clinical relevance, and acceptance. Thus, during the telerehabilitation interaction, the speech-language intervention occurred identically to the face-to-face method, that is, with explanations about the procedures, solicitations of tasks, samples of examples of voice production, correction of deviated vocal behaviors, and ratifications of appropriate voice emissions.

Similar to other studies<sup>(15,24,25)</sup>, there were technological adversities such as poor Internet connection and temporary loss in audio and video resolution, but there was no impediment of sessions or interruption of the telerehabilitation. Regardless the technological attributes used by the patients, the videoconference resources allowed fidelity and quality in interactions.

As exposed, this study demonstrated that telerehabilitation has great potential for perceptual evaluation and voice treatment of patients with PD. Still, it was essential to know the opinion of patients about this modality of treatment, through the answers obtained with the satisfaction questionnaire.

When questioned, all patients reported to prefer telerehabilitation. Most of them mentioned satisfaction and positive impression about the audio and video. These answers, probably, are due to the quality of the interactive dynamics, comfort, convenience, and independency.

It is important to mention there were no cases of absence or dropout, as well as no patients preferred or were recommended to face-to-face rehabilitation, which leads us to believe that telerehabilitation may improve the adherence to speech language treatment, sometimes hindered in traditional speech-language therapy by physical, family, social, geographic, and economic factors.

The results of this study suggest that the perceptual analysis and voice treatment may be performed by videoconference, pointing out that telerehabilitation seems to be efficient for the speech-language approach and that it may be accepted by patients with PD.

One must interpret these data with caution, once the participants of this study have voluntarily applied to it, lived in metropolitan areas, used to deal with computers, knew technologies, and used the Internet. It is likely that the acceptance of telerehabilitation has occurred in this sample of patients due to the overall profile described in association with some difficulties in basic and instrumental daily living activities. Perhaps these patients were more likely to best accept telerehabilitation.

In agreement to the previous research, for patient users of technologies, the approach was incorporated as one more resource to simplify daily routine, and maximize time and potentialities<sup>(26)</sup>. Thus, it is possible to infer that patients without access to technologies and with more preserved functional abilities present greater resistance to accept telerehabilitation.

Taking into account the multidimensional questions, despite the encouraging and promising results, the authors recognize the limitations of this study, with the absence of vocal self-perception, patients without technological experience, living in rural or remote areas and with attention loss, as well as the inclusion of acoustic and laryngeal analysis, measures which could allow analyzing the competence of telerehabilitation for diagnosis.

The results obtained in this study indicate that telerehabilitation has a potential to improve the conditions of voice quality of patients with PD. At first, the intervention seems viable and efficient; however, other studies, with a greater number of patients, are required in order to discuss validity, reliability, effectiveness, and efficacy for the approaches not addressed in this manuscript, such as the comparison to face-to-face rehabilitation.

Voice telerehabilitation offers many attractions for both speech language therapists and patients; therefore, the expectation is that future results may guide clinical conducts, referencing interventions, and changing health policies.

## CONCLUSION

Telerehabilitation was proven as an efficient method to eliminate or reduce signs of voice quality with accompanying PD, and it may be indicated for patients with access to technologies, in order to optimize vocal health.

The application of the procedures described in this study has the potential to evaluate and treat voice quality by telerehabilitation. These tools allowed the analysis of efficiency of telerehabilitation as there were observed vocal improvements resulting from behavioral speech language treatment by LSVT-X.

The synchronous intervention, pointed out as satisfactory by patients, is likely to produce good functional results with safety and convenience.

## ACKNOWLEDGEMENTS

To the Fundação de Amparo à Pesquisa do Estado de São Paulo – FAPESP, process no. 11/51667-0, for the financial support.

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## Author contributions

AED is the speech therapist responsible and performer of the research. She selected, evaluated, and telerehabilitated the patients, as well as performed and registered all the information regarding the telerehabilitation process (informed consents and clinical outcomes); JCPL is a neurologist researcher. He selected and evaluated all patients and was responsible for the revision to the English version; ERB is a neurologist co-supervisor and is responsible for the research. He selected patients and guided them on the clinical aspects of the research; WTH is a medical professor in telemedicine and research advisor. He developed and implemented the resources for telerehabilitation as well as oriented on the technological aspects of the research.