



Voice and swallowing effects after expiratory muscle strength training program in Parkinson's Disease

Efeitos na voz e deglutição após treino de força muscular expiratória na Doença de Parkinson

Efectos en la voz y en la deglución post entrenamiento de fuerza muscular espiratoria en la Enfermedad de Parkinson

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Abstract

The goal of this research is to evaluate the effects of an expiratory muscle training program on voice and swallowing. Parkinson's disease is a neurodegenerative condition with impacts on voice and swallowing. Muscle rigidity, which is common in Parkinson's disease, is global and affects the respiratory muscles, causing respiratory disorders and voice and swallowing difficulties. Six participants diagnosed with Parkinson's disease participated in this study. They were submitted to an eight-week therapeutic intervention focusing on expiratory muscle training. The therapeutic sessions occurred weekly at the institution and the participants were encouraged to perform the proposed exercises at home twice a week. The self-perception of swallowing problems was collected before and after intervention and voice analysis, as well as the respiratory parameters, were collected before, in the fourth week and at the end of the training program. In general, the results showed improvement in respiratory parameters. The

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TMFCSi: Definition of methodology, data collection, interpretation and analysis, article writing.

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voice parameters did not present significant differences after training. The self-perception of swallowing problems changed after training as some complaints disappeared and the participants reported new ones. The findings may have been influenced by time of disease and individual characteristics of each participant. During the training program, the participants presented improvements in exercise performance, which suggests a motor learning. The effects of expiratory muscle exercises may be greater if combined with other therapeutic interventions.

Keywords: Parkinson Disease; Voice; Respiration; Swallowing.

Resumo

O presente trabalho teve como objetivo avaliar os possíveis efeitos de um treino de força muscular expiratória na voz e deglutição de sujeitos com Doença de Parkinson. A Doença de Parkinson é neurodegenerativa e possui dentre seus sintomas alterações na voz e na deglutição. Devido à rigidez muscular geral, característica da doença, os músculos respiratórios também são afetados, gerando alterações em todo o sistema respiratório e influenciando diretamente nos sintomas vocais e de disfagia. Seis participantes diagnosticados com doença de Parkinson foram submetidos ao treinamento proposto, que consistiu em uma intervenção fonoaudiológica com duração total de oito semanas com aplicação exclusiva de exercícios de força muscular expiratória em grupo uma vez por semana, e também em domicílio duas vezes por semana. Antes e após a intervenção, foi realizada a auto-avaliação da deglutição, avaliação vocal e dos parâmetros da capacidade respiratória, além de uma avaliação intermediária. Foi possível encontrar nos resultados da avaliação pós-intervenção, de uma maneira geral, melhora nos parâmetros respiratórios, com aumento nas medidas coletadas da capacidade respiratória. Os parâmetros vocais utilizados não foram sensíveis a possíveis mudanças ocasionadas pelo treinamento. As variações nos resultados podem ser relacionadas ao tempo de doença de cada um e às suas manifestações individuais. No decorrer do treinamento proposto, os sujeitos apresentaram maior destreza em realizar os exercícios, melhorando sua execução e mostrando que houve aprendizado motor durante o treinamento proposto. Entretanto, sugere-se a realização de exercícios de força muscular expiratória em concomitância com outros tipos de intervenções para melhores resultados.

Palavras-chave: Doença de Parkinson; Voz; Respiração; Deglutição.

Resumen

El presente trabajo tuvo como objetivo evaluar los posibles efectos de un entrenamiento de fuerza muscular espiratoria en la voz y deglución de sujetos con Enfermedad de Parkinson. La Enfermedad de Parkinson es neurodegenerativa y posee entre sus síntomas alteraciones en la voz y en la deglución. Debido a la rigidez muscular general característica de la enfermedad, los músculos respiratorios son afectados, generando alteraciones en todo el sistema respiratorio e influyendo directamente en los síntomas vocales y de disfagia. Seis participantes diagnosticados con Enfermedad de Parkinson fueron sometidos al entrenamiento propuesto, que consistió en una intervención fonoaudiológica con una duración total de ocho semanas, con aplicación exclusiva de ejercicios de fuerza muscular espiratoria, en grupo, una vez por semana, y también el domicilio dos veces por semana. Antes y después de la intervención, fue realizada autoevaluación de la deglución, evaluación vocal y de los parámetros de la capacidad respiratoria, además de una evaluación intermedia. Fue posible encontrar en los resultados de la evaluación post intervención, de una manera general, mejoría en los parámetros respiratorios, con aumento en las medidas de la capacidad respiratoria. Los parámetros vocales utilizados no fueron sensibles a posibles cambios ocasionados por el entrenamiento. Las variaciones en los resultados pueden estar relacionadas al tiempo de enfermedad de cada uno y a sus manifestaciones individuales. Durante el transcurso del entrenamiento propuesto, los sujetos fueron presentando mayor destreza para realizar los ejercicios, mostrando que hubo aprendizaje motor durante el entrenamiento propuesto. Sin embargo, se sugiere la realización de ejercicios de fuerza muscular espiratoria en concomitancia con otros tipos de intervenciones para mejores resultados.

Palabras claves: Enfermedad de Parkinson; Voz; Respiración; Deglución.

Introduction

Parkinson's disease (PD) is the second most common neurodegenerative disease among individuals over 64 years of age in Brazil, second only to Alzheimer's disease¹. The disease is mainly characterized by a movement disorder that generates symptoms such as resting tremor, bradykinesia, muscular rigidity and postural instability. These symptoms influence the voice and speech of patients turning into dysarthria.

Dysarthria in PD is typically characterized by hoarseness, weak and monotonous voice, prosody and intensity alteration, and articulatory inaccuracy². In addition, swallowing disorders are frequently reported in the literature, characterized by changes in food bolus conduction and delayed onset of swallowing, leading to choking episodes due to food penetration or aspiration^{3, 4}.

Phonation and the laryngeal function of protecting the lower airway may also be altered due to respiratory muscle strength restriction caused by stiffness of the thoracic wall, which may lead to a reduction of maximal inspiratory and expiratory pressures and pulmonary volumes⁵.

Individuals with PD present with overall muscle strength restriction due to stiffness. Postural changes that generate trunk flexion, common features of PD, along with chest wall stiffness, may contribute to a decrease in chest amplitude, limiting inspiratory and expiratory capacities⁷ and, consequently, reducing the laryngeal protection function of the lower airways as well as phonation.

Respiratory muscle strength training techniques have been evaluated as a way to improve voice and swallowing in patients with PD⁸. Specifically, breathing can be trained through inspiratory and expiratory muscle strength exercises⁹.

One study used wind instruments (instrumentos de sopro) with two subjects with PD in order to verify their effects on phonation and breathing. One study looked at the effects of PD on phonation respiration in two subjects. As part of the study procedure, after the videolaryngoscopic exam, respiratory function evaluation, voice sample recording, and vocal intensity measures were performed before and after the 12-week intervention. High intensity posture exercises, manual laryngeal repositioning, and blowing exercises were performed. The results showed positive changes in breathing, acoustic analysis and vocal intensity. Improved

vocal fold adduction and breath control provided improved vocal quality and a more effective use of air for phonation, proving the effectiveness of therapeutic intervention with blowing instruments¹⁰.

In another study, the authors looked at the effects of respiratory muscle strength exercises on voice and swallowing in subjects with PD. The authors used a device to perform respiratory strength exercises for four weeks. Participants were asked to inhale deeply and then blow into the device until their maximum expiratory pressure was reached. The study concluded that respiratory muscle strength exercises promoted a significant increase in maximal expiratory pressure, with a positive effect on voice and above all swallowing, reducing the risk of aspiration by providing greater glottal closure and favoring the protection of the lower airways⁸.

Other researchers studied respiratory muscle strength in three men and two women with PD, in relation to posture and vocal parameters such as maximum phonation time (MPT) and vocal intensity. The results were compared with a control group of individuals without the disease. Gender, stage of the disease and level of physical activity were considered for the evaluation of the measures collected. A gender difference was observed. Men with PD presented with lower respiratory muscle strength, MPT and vocal intensity values. On the other hand, women without the disease and those in a less advanced stage of it who practiced physical activity demonstrated better vocal parameters and respiratory muscle strength results, while women with PD showed reduced vocal intensity¹¹.

According to the literature, respiratory strength training may benefit the phonation and swallowing functions of individuals with PD. These individuals often present with such altered functions as the disease progresses, due to damage to the laryngeal closure, which can lead to communication difficulties and consequently to social isolation. Swallowing difficulties may also occur due to difficulty in protecting the lower airway, leading to penetration and aspiration of food or liquid.

The purpose of this study is to evaluate the effects of a respiratory muscle strength training program on phonation and deglutition in individuals with Parkinson's disease.

Method

This is a cross-sectional study, of quantitative and qualitative nature, which presents the results of a series of case studies, approved by the Research Ethics Committee of UNICAMP under the protocol number 1,085,790.

Subjects

Six subjects participated in this study, aged between 40 and 70 years (mean age 58 years, standard deviation 11.4) who were part of the Gabriel Porto (CEPRE) Parkinson's Speech-Language Pathology Rehabilitation group. The subjects bean the proposed training after signing the Free and Informed Consent Form

Inclusion criteria to participate in the study were: a) to be between 40 and 70 years of age; and b) to have a medical diagnosis of Parkinson's Disease. Individuals who did not have medical approval to work with phonatory effort and who had other neurological diagnoses concomitant with PD were excluded from the study.

The participants in this study were part of the institution's Parkinson's Group and presented with no language and memory changes at the time of data collection (in these cases, subjects with PD were referred for individual therapy), allowing to also complete a self-assessment questionnaire on swallowing.

Evaluation procedure

Procedures to evaluate the effects of the proposed training were performed before, after and during the execution of the therapeutic intervention. The first training session occurred after the initial evaluation, during the first week of intervention. The post-intervention evaluation was performed the week after the eighth week of training.

Maximum phonation time (MPT) and s / z ratio were collected to evaluate the effects on the individuals' voice using the sustained vowel / a / and the consonant / s / and / z /, to verify the respiratory dynamics as well as the equilibrium of the aerodynamic and myoelastic forces of the larynx¹².

The possible effects of the training on swallowing were assessed with a swallowing self-assessment questionnaire, contained in the dysphagia evaluation protocol of the institution where the study was performed¹³. In this questionnaire, the subjects answered questions about their overall

swallowing complaints, including the degree and frequency in which they occur. The questionnaire was applied in the pre- and post-intervention evaluations.

Finally, respiratory parameters were assessed using a Spirometer model Spir Micro C. The functional vital capacity (FVC) measures were collected to measure the maximum air volume that the individual was able to expel from spirometry and forced lung volume (FEV) which refers to the maximum volume that the subject can exhale in one second of maximum expiration¹⁴.

In addition to the pre- and post-intervention assessments, an intermediate evaluation was performed during the fourth week of training, focusing only on respiratory parameters using a spirometer and a voice evaluation.

Therapeutic intervention

The proposed therapeutic intervention occurred weekly in group for 1 hour. Prior to the participation in the study, a conversation was held with the relatives and caregivers of the participants, emphasizing the need for support to perform the given exercises outside the therapeutic environment. Due to the type of facilities the participants belonged to, it was not possible to carry out intervention more than once a week.

The therapeutic process design was based on the proposal of another study⁸, with modifications pertinent to the service in which the participants were allocated. In addition to the weekly group training sessions, the exercises were to be performed at home, on their own or with the help of a family member, twice a week, for a total of three weekly training sessions. The number of repetitions per session gradually increased throughout the training period, starting with ten repetitions per session. Each participant received a table to be filled in whenever the exercise was performed, to control the frequency of execution of the exercises at home.

During the group training, three exercises were adopted that followed a pre-established order. The selected exercises consisted of: a) blowing balloons (an adaptation of the principle used by the authors of the baseline study, since it is necessary that the participant undergoes minimal pressure to start performing the requested task); B) complete diaphragmatic breathing, which is characterized by a total and harmonic expansion of the entire thoracic

cavity¹⁵, and c) training respiratory strength after deep inhalation and direct exhalation into specific nozzles of the spirometry apparatus. Patients were asked to perform the balloon blowing procedure with a maximum of five expiratory movements and, as in the complete diaphragmatic breathing procedure, the training period began with three repetitions, followed by up to five repetitions of each exercise towards the end. The direct exhalation into specific nozzles of the spirometer at the beginning of the training was performed with five repetitions, reaching ten by the end of the study. The exercises were performed in a seated position and supervised by speech-language pathologists who coordinated the group. These were the only exercises that were performed during the eight consecutive weeks between pre-intervention and post-intervention evaluation.

Analysis of results

The statistical analysis of the results concerning MPT and spirometric parameters was performed using the free software R (www.r-project.org). The test conducted was the ANOVA for Repeated Measures (p <0.05) to assess possible differences between the three analyzed moments (pre, intermediate and post-training moments). For the study of the effects of swallowing, qualitative and quantitative aspects were analyzed regarding the subjects' answers.

Results

Figure 1 identifies data of the subjects, related to gender, age and disease duration.

Subjects	Gender	Age	Disease duration
1	Male	69	4 years
2	Male	70	15 years
3	Male	55	5 years
4	Female	61	9 years
5	Female	40	13 years
6	Male	64	18 years

Figure 1. Characterization of the sample

Table 1 presents the results obtained in each spirometric evaluation.

Table 2 shows the mean and standard deviation of each parameter evaluated, as well as the results obtained after the statistical analysis.

Tables 3, 4, 5, 6 and 7 present the results obtained per subject of each of the parameters evaluated during the three moments of analysis.

Table 1. Results obtained for spirometry. Values obtained in pre-intervention, intermediate evaluation and post-intervention

Subjects	Spirometry									
	FVC					FEV				
	Pre	Int	% Pre-Int.	Post	% Int-Post	Pre	Int	%Pre-Int.	Post	% Int-Post
Subject 1	1,44	3,58	248%	4,41	123%	1,42	2,22	156%	3,25	146%
Subject 2	1,97	0,97	-51%	2,27	234%	1,97	0,95	-52%	2,26	237%
Subject 3	2,17	3,16	145%	3,8	120%	1,83	3,16	172%	3,57	112%
Subject 4	0,84	2,5	297%	2,82	112%	0,84	2,43	289%	2,74	112%
Subject 5	2,84	4,99	175%	1,32	-74%	2,84	4,93	173%	1,32	-74%
Subject 6	3,54	1,72	-52%	2,86	166%	2,64	1,72	-35%	2,84	165%

Legend¹
 FVC: values of forced vital capacity
 FEV: Forced Expiratory Volume

Table 2. Results of the pre-intervention, intermediate and post-intervention evaluations, with average values collected during maximum phonation time and spirometry after statistical anova testing for repeated measures.

Parameter	Evaluation Pre		Evaluation Intermediate		Evaluation Post		P Value
	Average	SD	Average	SD	Average	SD	
MPT /a/	14	4,64	12	6,18	13,8	6,67	0.325
MPT /s/	7	3,68	7,1	2,92	8,83	6,04	0.902
MPT /z/	8,3	2,73	7,5	2,34	8	3,94	0.612
s/z	0,83	0,28	0,92	0,31	1	0,27	0.362
FVC	2,13	0,96	2,82	1,42	2,91	1,09	0.208
FEV	1,92	0,74	2,56	1,37	2,66	0,79	0.146

Legend²

MPT = maximum phonation time

FVC = values of forced vital capacity

FEV = Forced Expiratory Volume

SD= Standard Deviation

Table 3. Individual results for maximum phonation time of sustained vowel [a] in seconds

	[a]		
	Pre	Int.	Post
Subject 1	19	18	20
Subject 2	14	14	3
Subject 3	19	11	16
Subject 4	11	6	9
Subject 5	7	6	15
Subject 6	14	21	20

Table 4. Individual results for maximum phonation time of fricative [s] in seconds

	[s]		
	Pre	Int.	Post
Subject 1	7	10	9
Subject 2	3	4	2
Subject 3	14	9	9
Subject 4	6	3	7
Subject 5	6	8	20
Subject 6	6	9	6

Table 5. Individual results for maximum phonation time of fricative [z] in seconds.

	/z/		
	Pre	Int.	Post
Subject 1	11	11	11
Subject 2	6	9	3
Subject 3	12	7	8
Subject 4	8	4	6
Subject 5	8	7	14
Subject 6	5	7	6

Table 6. Individual results for s/z ratio

	s/z Ratio		
	Pre	Int.	Post
	0,63	0,9	0,8
	0,5	0,4	0,6
	1,16	1,2	1,12
	0,75	0,75	1,1
	0,75	1,1	1,4
	1,2	1,2	1

Table 7. Functional vital capacity and forced spirometric (or expiratory) volume

	FVC			FEV		
	Pre	Int.	Post	Pre	Int.	Post
Subject1	1,44	3,58	4,41	1,42	2,22	3,25
Subject2	1,97	0,97	2,27	1,97	0,95	2,26
Subject3	2,17	3,16	3,8	1,83	3,16	3,57
Subject4	0,84	2,5	2,82	0,84	2,43	2,74
Subject5	2,84	4,99	1,32	2,84	4,93	1,32
Subject6	3,54	1,72	2,86	2,64	1,72	2,84

Figure 2 shows the complaints related to deglutition that decreased towards the end of the proposed intervention.

Reduced Complaints	N
Reduced choking	3
Decreased sensation of food stuck in the throat	2
Reduced difficulty to swallow	2
Reduced nasal regurgitation	1
Reduced oral residue	1
Reduced chewing pain	1
Presence of smell and taste	1
Reduced food stuck on the palate	1
Reduced phlegm after the pharyngeal swallowing phase	1

Figure 2. Reduced complaints after expiratory (respiratory) muscle force training

Discussion

The exclusive and prolonged expiratory muscle strength training in a group of six subjects with PD and its effects on vocal parameters and self-evaluation of swallowing were analyzed considering inter and intra-subject results. The analysis of the group as a whole did not present statistical significance ($p < 0.05$), which may be related to the small number of subjects that compose the studied group. However, intra-subject analysis presented

significant changes and may reinforce the benefits of the use of expiratory muscle strength training in the clinical practice of subjects with PD.

The spirometry assessment of each individual subject during the three analyzed moments showed an increase in the value of FVC, which indicated improvement in the maximum volume of air that the individual was able to expel from the lungs. The increase in the value of FEV refers to the improvement in the maximum volume that the subject can exhale in one second of maximum ex-

piration¹⁴. Improvement in these aspects can have a direct impact, for example, on the production of an effective cough, and allow greater airway protection of the airway during laryngeal penetration or aspiration. Considering the magnitude of change in the results obtained in the three moments and an intra-subject analysis, some participants showed an increase of up to 297% for FVC and 289% for FEV (TABLE 1). Previous study⁸ also evaluated respiratory parameters in subjects with PD (maximal inspiratory pressure and maximal expiratory pressure), after expiratory muscle strength training. The results showed improvement after therapy (but not significant when considering the group as a whole). Thus, data from the present study indicated that respiratory parameters may show good results after expiratory muscle strength training, even in group intervention and with a reduced number of weekly sessions.

The parameters related to phonation (MPT) and swallowing (self-perception questionnaire) varied in relation to the subjects studied and, therefore, the statistical analysis also did not show a significant improvement considering the group as a whole.

However, even by only performing expiratory muscle strength exercises, the same voice production values found at the time of pre-intervention were maintained. The mean MPT for sustained vowel was 14 seconds at the beginning of the training and 13.8 seconds at the end of the training. The obtained values, although not statistically significant, can be considered adequate if we consider the effects that PD can have on phonation and respiration. The time of diagnosis of the disease may have influenced the obtained results as well. Although no statistical correlation test was performed, it was observed that the subject who sustained an adequate MPT of the vowel [a] was more recently diagnosed (subject 1) than the subjects who had reduced MPT and were diagnosed for nine years or more (subjects 2 and 4).

The s/z ratio values obtained were statistically non-significant ($p < 0.05$). However, after the training the s/z ratio began to improve, with values closer to one, demonstrating a better balance between the aerodynamic and myoelastic forces of the larynx¹. MPT evaluation of subjects with PD before and after treatment with wind instrument, with a focus on respiratory muscle strength training, was previously studied and found to have the opposite

results than the ones obtained by this study¹⁰. The author found an increased time of emission of the vowel [a] and a decreased s/z ratio were found, with the prevalence of strain to the emission. It should be noted that the previous study evaluated only two subjects and did not perform a statistical analysis to confirm the results.

The self-perception assessment on swallowing did not show any consistent changes between pre and post-intervention. Figure 2 shows that most of the complaints that decreased after training were related to decreased choking episodes since the beginning of the proposed training. However, new complaints began to emerge, such as 'liquid and saliva escape from the mouth' and 'food residue in the oral cavity'. The emerging of new complaints may be due to the fact that the therapeutic techniques performed were not directed at targeting dysphagia.

The results suggest that expiratory muscle strength training may work best in conjunction with other available techniques for the management of voice and swallowing in subjects with PD. It is important to note that the data obtained specifically for swallowing changes, were self-reported by the participants, and no objective evaluation of swallowing was performed. In future studies, clinical and objective evaluation of swallowing could provide more information about the effectiveness of this training on the same.

Considerations regarding the proposed training

The exercises of the proposed training program were performed with a gradual increase of intensity, in accordance to each participant's individual performance. Thus, each week, the amount and frequency of the exercises were reviewed by the researchers and customized according to each participant's performance.

The use of a self-perception questionnaire can be considered controversial because of the possible presence of cognitive alterations, common in PD. However, although cognitive skills were not tested before the beginning of the experiment, they were taken into consideration in the choice of the subjects that composed the sample of this study, reinforcing the validity of the answers obtained in the questionnaire.

The result comparison between the initial and final moments of training demonstrated that some participants presented with worsened or same

evaluation aspects. An intermediate evaluation during the fourth week of training was important for the overall evaluation of the proposed training. During this evaluation, the subjects presented with improvement, specifically for the s/z ratio, over the first and the eighth week, demonstrating a peak of improvement during the first month of intervention.

During the training period, it was possible to note an improvement in the individual performance of the participants in several aspects, such as the ability to perform the requested exercises and show decreased fatigue when performing the same. The observed change came from the practice of repeated movements, thus demonstrating improvement of the performance of the subject¹⁷.

Due to the results obtained, the hypothesis that muscular training of expiratory force occurring in an isolated and prolonged way was not enough to minimize the complaints of voice and swallowing in subjects with PD. Respiratory exercises are important and may generate important results, such as increased expiratory capacity. However, they may be a more effective strategy when combined with other methods, at least for the population of the present study.

It should also be noted that the studied population consisted of only six subjects, and that the exercises assigned were performed only once a week. Future studies are recommended with a larger population and greater exercise frequency than weekly performance.

Conclusion

The effects of exclusive and long-term expiratory muscle strength training on voice and swallowing of subjects with PD did not show significant changes in the parameters studied, in relation to the group as a whole. However, the analysis of each case showed a considerable increase in maximum expiratory capacity, suggested by the increase in functional vital capacity and forced expiratory volume.

The duration of the disease, as well as its individual manifestations, may have affected each subject differently. Despite this, during the course of the proposed training, the subjects improved their skills in performing the exercises, suggesting a motor learning process during the training proposed.

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