

Photobiomodulation in Speech, Voice and Swallowing Dysfunctions in Individuals with Parkinson's Disease: a Systematic Review

Fotobiomodulação em Disfunções de Fala, Voz e Deglutição em Pessoas com Doença de Parkinson: uma Revisão Sistemática

Fotobiomodulación en los trastornos del habla, la voz y la deglución en personas con enfermedad de Parkinson: una revisión sistemática

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Abstract

Introduction: Photobiomodulation or laser is defined as a therapeutic resource that emits red and infrared light, which facilitates and enhances the results obtained in speech therapy. **Objective:** The objective is to develop a systematic review on the use of Photobiomodulation in speech, voice and swallowing dysfunctions in elderly individuals with Parkinson's Disease. **Methods:** This Systematic Review had its protocol registered in PRÓSPERO, with number CRD42023414037. The descriptors selected in DeCS and MeSH: "Parkinson Disease, Low Level Laser Therapy, voice, dysarthria, dysphagia". The search was carried out in the databases: PubMed, LILACS, EMBASE, Cochrane Central Register of Controlled Trials, Science Direct, Web of Science and Scopus. And the gray literature databases

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Authors' contributions:

RSAP, NTA: study design; data collection; and/or data analysis/interpretation; drafting or reviewing the manuscript; approving the final version of the manuscript for publication; and taking responsibility for the accuracy and integrity of all aspects of the research.

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Google Scholar and Open Grey. **Results:** Following the PRISMA diagram (2020), 422 articles were found in the Identification. Thirty-five duplicate articles were removed from the total number of articles in the EndNote search. Soon after, 341 articles were excluded, leaving 46 articles for full reading. After excluding articles that presented the wrong source (n=3), study results (n=35) or comparator (n=4) of the results, 4 articles were selected in the Included topic of PRISMA (2020) for this SR. The publications were described in tables with outcomes for voice, speech or swallowing. **Conclusion:** Randomized clinical trials are necessary to enhance evidence-based practice even with good results in speech therapy for voice, speech and swallowing with the application of Photobiomodulation in Parkinson's Disease.

Keywords: Parkinson's disease; Photobiomodulation; Voice; Dysphagia; Speech.

Resumo

Introdução: A Fotobiomodulação ou laser é definida como um recurso terapêutico de emissão de luz vermelha e infravermelha, que facilita e potencializa os resultados obtidos na fonoterapia. **Objetivo:** O objetivo é desenvolver uma revisão sistemática sobre a utilização da Fotobiomodulação nas disfunções de fala, voz e deglutição em pessoas com Doença de Parkinson. **Métodos:** Esta Revisão Sistemática (RS) teve seu protocolo cadastrado no PRÓSPERO, com número CRD42023414037. Os descritores selecionados no DeCS e MeSH: "Parkinson Disease, Low Level Laser Therapy, voice, dysarthria, dysphagia". A busca foi realizada nas bases de dados: PubMed, LILACS, EMBASE, Cochrane Central Register of Controlled Trials, Science Direct, Web of Science e Scopus. E as bases de dados de literatura cinzenta Google Scholar e Open Grey. **Resultados:** Seguindo o diagrama PRISMA (2020), na *Identificação* foram encontrados 422 artigos. Removidos 35 artigos duplicados do total de artigos da busca pelo EndNote. E logo após, foram excluídos 341 artigos, ficando 46 artigos para a leitura completa. Após a exclusão dos artigos que apresentaram fonte (n=3), resultados dos estudos (n=35) ou comparador (n=4) dos resultados errados, foram selecionados 4 artigos no tópico *Incluídos* do PRISMA (2020) para esta RS. As publicações foram descritas em tabelas com desfecho para voz, fala ou deglutição. **Conclusão:** Torna-se necessário ensaios clínicos randomizados para potencializar a prática baseada em evidência mesmo com bons resultados na terapia fonoaudiológica para voz, fala e deglutição, com aplicação da Fotobiomodulação na Doença de Parkinson.

Palavras-chave: Doença de Parkinson; Fotobiomodulação; Voz; Disfagia; Fala.

Resumen

Introducción: La fotobiomodulación se define como un recurso terapéutico que emite luz roja e infrarroja, que facilita y potencia resultados obtenidos en logopedia. **Objetivo:** El objetivo es desarrollar revisión sistemática sobre el uso de Fotobiomodulación en los trastornos del habla, la voz y la deglución en personas mayores con Enfermedad de Parkinson. **Métodos:** Esta Revisión Sistemática tuvo su protocolo registrado en PROSPERO, con el número CRD42023414037. Los descriptores seleccionados en DeCS y MeSH: "Enfermedad de Parkinson, Terapia con Láser de Bajo Nivel, voz, disartria, disfagia". La búsqueda se realizó en las siguientes bases de datos: PubMed, LILACS, EMBASE, Registro Cochrane Central de Ensayos Controlados, Science Direct, Web of Science y Scopus. Las bases de datos de literatura gris Google Scholar y Open Gray. **Resultados:** Siguiendo el diagrama PRISMA (2020) se encontraron 422 artículos en Identificación. Se eliminaron 35 artículos duplicados del total de artículos en búsqueda de EndNote. Y poco después, se excluyeron 341 artículos, quedando 46 artículos para lectura completa. Después de excluir los artículos que presentaron la fuente incorrecta (n=3), los resultados del estudio (n=35) o el comparador (n=4) de los resultados, se seleccionaron 4 artículos en el tema Incluido de PRISMA (2020) para esta RS. Las publicaciones se describieron en tablas con resultados para la voz, el habla o la deglución. **Conclusión:** Son necesarios ensayos clínicos aleatorios para mejorar práctica basada en evidencia incluso con buenos resultados en logopedia para la voz, el habla y deglución con aplicación de Fotobiomodulación en Enfermedad de Parkinson.

Palabras clave: Enfermedad de Parkinson; Fotobiomodulación; Voz; Disfagia; Habla.

Introduction

Parkinson's Disease (PD) has been presented as one of the most prevalent neurodegenerative diseases worldwide. Some authors¹ who research the subject report that there is a sharp increase in the incidence of PD above the age of 65, with approximately one in every 50 people over the age of 80 having been diagnosed with PD.

As PD progresses, the disabilities that arise cause the deregulation of neural circuits in the basal ganglia, whose main function is to control movement². Neurons that have the lowest energy intensity are the most vulnerable, since the decrease in cellular energy production demonstrates the deficiency in mitochondrial function (energy production) as a pathogenic process of PD².

One of the main characteristics of PD is the selective degeneration of dopaminergic neurons in the substantia nigra compacta, which exerts a considerable influence on muscle tone².

Low Level Laser Therapy (LLLT) is a therapeutic resource that has been used for several years in the treatment of various pathologies or diseases³. However, the use of Photobiomodulation (PBM) as a therapeutic resource in the rehabilitation of patients with PD is recent and clinical research on this topic is still scarce in the literature.

Photobiomodulation complements traditional therapy in Speech Therapy with laser technology that emits red and infrared light, modulating biological tissue and bringing benefits to facilitate and enhance the results obtained⁴. There are still gaps in the scientific evidence for Photobiomodulation in its applicability in individuals with PD, and studies using Brain Photobiomodulation are frequent, both experimentally in animals and in humans. However, the use of Photobiomodulation in peripheral regions, in areas of the Stomatognathic System (SS) or in its speech, swallowing and voice functions for PD is still little known. It is of fundamental importance to carry out a Systematic Review on the use of Photobiomodulation as a resource in order to enhance the therapeutic results of Speech Therapy in the speech, voice and/or swallowing of individuals with PD.

This study aimed to develop a systematic review of studies that used Photobiomodulation as a technological resource to improve speech, voice and/or swallowing in individuals with PD.

Method

The protocol for this Systematic Review (SR) was registered on the International Prospective Register of Systematic Reviews (PROSPERO) platform, with number CRD42023414037. This protocol included: the research question, the criteria used to select articles in the data platforms, the eligibility criteria, the extraction of data from the documents, the data analysis, and the ways to explore the outcomes that were evaluated. The articles included in this SR were not limited by language or year of publication.

The acronym PICOS (Patient, Intervention, Comparison, Outcomes, and Study design) was used to answer the formulation of the research question, which was as follows: Does the applicability of Photobiomodulation as a therapeutic resource for Speech Therapy help in the production of speech, voice, and swallowing in individuals with Parkinson's?

Types of participants

The types of participants in the research investigated and included were those with individuals with Parkinson's Disease by neurological diagnosis. Age and duration of PD diagnosis were not considered. They could be using any drug therapy or any duration of treatment.

Types of interventions

The interventions included in this Systematic Review were those that used Photobiomodulation to improve speech, voice and/or swallowing versus placebo intervention or no intervention.

Type of Comparison

Other strategies used in the studies were found other than those related to Photobiomodulation.

Types of outcome measures

The expected outcomes as outcome measures could be related to improvements in voice, speech or swallowing, or with more specific results such as improvements in maximum phonation time (MPT), vocal intensity gain, improvement in fundamental frequency (F0), reduction in vocal tremor/instability, reduction in jitter and shimmer, improvement in cepstral peak prominence (CPPS) measurements, improvement in oral transit time during swallowing, reduction in signs and symptoms of

dysphagia (coughing, choking), reduction in signs and symptoms in speech before and after intervention/treatment, with the use of Photobiomodulation for individuals with Parkinson's Disease. In the area of voice, acoustic and aerodynamic measures were considered, such as MPT, and in the area of swallowing, protocols for measuring swallowing parameters such as signs and symptoms of Dysphagia. Types of studies

The types of studies included were theoretical conceptual studies, such as integrative or systematic reviews, or empirical intervention studies, with randomized or nonrandomized clinical trials or other studies that addressed the use of Photobiomodulation in individuals with PD.

Search methods for identifying studies

The identification of terms and descriptors was performed on the Health Sciences Descriptors - DeCS and Medical Subject Heading - MeSH platform, according to the topic studied, the therapeutic resources and outcomes used for the Parkinson's population included in this review.

The terms found were used to plan the research strategy carried out in this systematic review. The descriptors used in this review were: "Parkinson Disease, Low Level Laser Therapy, voice, dysarthria, dysphagia, speech" and their corresponding terms in Portuguese "Doença de Parkinson, Laser de Baixa Intensidade, voz, disartria, disfagia, fala". They were used with the AND and OR markers according to the combinations between the descriptors in the databases searched.

The databases searched were: PubMed, Cochrane Central Register of Controlled Trials, Embase, Scopus, Web of Science, Scielo, Lilacs, Science Direct, Medline. The gray literature databases Google Scholar (<http://scholar.google.pt>); and Open Grey (<https://opengrey.eu/>) also participated in the research.

Data collection and analysis

We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), in its updated 2020 version, a protocol recommended for better assertiveness in reporting what will be found in systematic reviews⁵.

It was not feasible to perform a meta-analysis in this SR, since after data extraction, the number of randomized clinical trial studies or studies with the outcomes proposed for this Systematic Review that had sufficient statistical information to perform a meta-analysis was not found in the database searches.

After completing the search for articles in the databases, they were exported to the ENdNote® reference manager (EndNote/Clarivate Analytics, PA, USA) where the articles were organized and duplicate articles were removed. The articles were then exported to the Rayyan® software (Qatar Computing Research Institute, Doha, Qatar) when the studies were selected blindly and independently, with records of the decisions kept on the platform. The articles were selected according to the eligibility criteria and the inclusion and exclusion criteria of the studies.

After data collection, the analysis, interpretation and discussion of the results followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocol (Prisma, 2020) for the preparation of the final report of this Systematic Review on the Applicability of Photobiomodulation in Speech, Voice and Swallowing Disorders in Individuals with Parkinson's.

Results

Following the PRISMA diagram (2020), in the Identification topic, 422 articles were found in the database search in the following locations: PubMed, Cochrane Central Register of Controlled Trials, Embase, Scopus, Web of Science, Scielo, Lilacs, Science Direct, Medline and in the gray literature databases Google Scholar and Open Grey. Thirty-five duplicate articles were removed from the total number of articles in the EndNote search. In the Screening topic, 387 articles were exported to Rayann with the selection and screening of these articles by reading the titles and abstracts. The articles that were excluded because they were not part of the research question were 341 articles, leaving a total of 46 articles for full reading after meeting the eligibility criteria for the database search proposed in the Systematic Review Protocol. After exclud-

ing articles with incorrect sources (n=3), results (n=35) or comparators (n=4), 4 articles selected from the Included topic of PRISMA (2020) were included for this SR. The vast majority of studies that were excluded were about Transcranial or Intranasal Photobiomodulation, studies that presented other outcomes, mainly in the area of

Language, in addition to some experimental studies in animals with the application of Transcranial Photobiomodulation.

Figure 1 below shows the PRISMA Diagram (2020) with the phases of Identification, Selection and Inclusion of the articles of this Systematic Review.

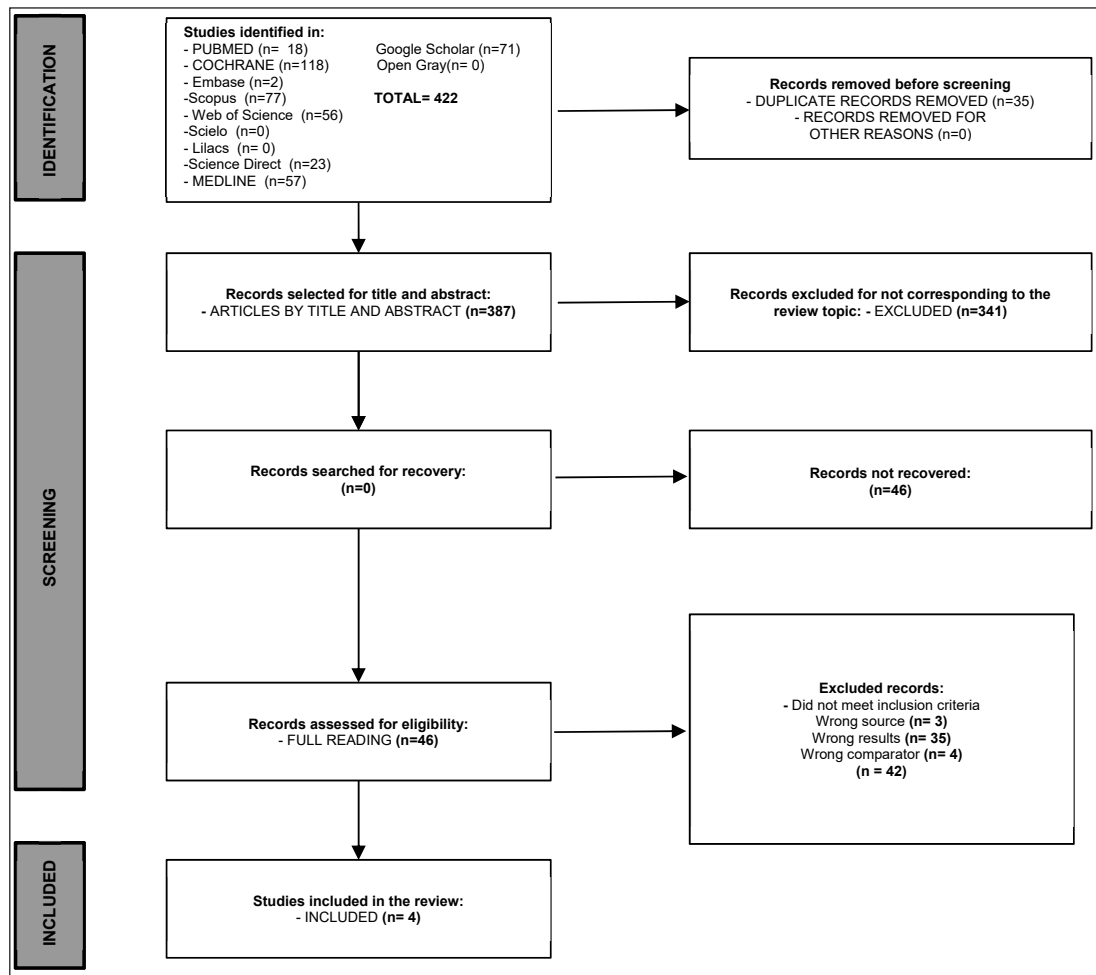


Figura 1. Fluxograma PRISMA (2020) - visão geral do processo de triagem e exclusão dos diferentes artigos

Description of studies

The description of the four studies included in this Systematic Review will be carried out with the main topics of the article analyzed in table form for later discussion of the findings and relevance to the scientific literature.

Table 1 presents the publications selected for this review that refer to theoretical or conceptual publications that used Photobiomodulation for the treatment of Parkinson's disease, identifying the authors and year of publication, place of publication, DOI, objectives, the method used, Photobiomodulation parameters, main findings and the conclusion of the study.



Table 1 - Description of theoretical or conceptual articles on Photobiomodulation as a treatment for voice, speech or swallowing in Parkinson's disease.

Authors/ year	Journal/publication doi	Type of study/ treatment technique	Objective	Photobiomodulation method/parameters	Main findings	Conclusion
Behlau, et al. (2022)	CoDas DOI: 10.1590/2317- 1782/20212021241pt	A.CONCEPTUAL OR THEORETICAL Photobiomodulation for voice treatment	Present analyses on aspects of vocal rehabilitation for traditional and modern electrostimulation and photobiomodulation techniques applied to vocal rehabilitation.	<ul style="list-style-type: none"> - The choice of dosimetric parameters is especially important in clinical applications. - The LASER used in vocal clinics is low-power and has no bionegative effects on the biological tissue that stimulates the body's physiology. - The most commonly used laser has a wavelength in the red (635-700 nanometers) and near-infrared (808-1100 nanometers) ranges. 	<ul style="list-style-type: none"> - Traditional therapy techniques: studies on traditional rehabilitation programs, methods or techniques, many with high quality evidence, consider such procedures to be relatively well described, safe and with known effects for the treatment of various vocal disorders. - Modern therapy techniques: Electrostimulation: - has already produced high-quality evidence on its effect in the treatment of certain dysphonias. - Photobiomodulation: <ul style="list-style-type: none"> - low-intensity LASER acts on muscle performance, reducing fatigue, increasing strength, muscle resistance and improving chemical markers - Used with caution in oncology, in the treatment of radiomucositis and xerostomia due to radiotherapy and chemotherapy - is seen as an adjuvant treatment and not as a sole resource in cases of dysphonia - can also be used for vocal conditioning - Photobiomodulation, by itself, is not capable of reabsorbing or eliminating lesions, nor does it influence behaviors that are harmful to the voice. 	<p>Despite its great clinical and scientific vitality, the field of voice, including the use of Photobiomodulation, still needs to advance in research to obtain better evidence.</p> <p>Reducing the gap between science, through research analysis, and vocal clinics, which should indicate which problems deserve investigation, should be a shared responsibility.</p>





Authors/ year	Journal/publication doi	Type of study/ treatment technique	Objective	Photobiomodulation method/parameters	Main findings	Conclusion
Sohail, et al (2023)	Journal of Mind and Medical Sciences DOI: 10.22543/2392-7674.1365	A.CONCEPTUAL OR THEORETICAL Systematic Review for the Treatment of Parkinson's Disease Using Photobiomodulation	To bridge the research gap and provide up-to-date data and productive information on the latest research reported in recent years to encourage PD treatment.	The literature search was performed by collecting recent data from different reviews, reports and original articles on general or specific rehabilitation therapies applied in patients with PD. The databases used included Science Direct, Pubmed and EBSCO, Google Scholar, as well as a manual search in journals and bibliographies. The search terms were: "Parkinson's disease" or "Parkinson's disease" or "Parkinsonism" or "Parkinsonian" and "repetitive transcranial magnetic stimulation" or "rTMS" or "repetitive TMS" or "theta burst stimulation" or "TBS".	Initially, 350 articles were selected, 199 of which were selected for detailed review on various therapies. The articles were described by area: Physical Therapy (34), Occupational Therapy (10), Speech Therapies (17), Dysphagia (9), Music (10), Hormonal (13), Genetics (17), Stem Cell (16), Light Therapy (17), Deep Brain Stimulation (18), Repetitive Transcranial Magnetic Stimulation (19). Speech Therapy: Scientists estimate that 89% of patients with PD have (laryngeal, respiratory and articulatory function disorders). -Despite the high incidence of speech and voice impairment, only 3 - 4% of patients with PD receive speech therapy. -The Lee Silverman Voice Treatment (LSVT® LOUD) has generated efficacy data for the successful treatment of voice and speech disorders in this population. - Clinical case reports have used a transcranial approach, with a handheld laser or light-emitting device (LED) or a helmet lined with many LED strips. - Clinical report showing improvement in speech, cognition, freezing episodes, and gait in 8 PD patients after 2 weeks of head-mounted photobiomodulation. - In 36 patients, intranasal photobiomodulation resulted in most parkinsonian signs (~90%).	Photobiomodulation (due to its lack of side effects and neuroprotective potential) is acceptable for use in conjunction with other treatments. Studies show that Photobiomodulation has the potential for neuroprotective function (protects neurons from degeneration and allows their recovery and restoration of functions), and is considered safe and there are no reported side effects.

Legend of acronyms: PD - Parkinson's disease Stroke - Cerebral vascular accident TMS - Transcranial Magnetic Stimulation rTMS - Repetitive Transcranial Magnetic Stimulation LSVT- Lee Silverman Voice Treatment.



Table 2 describes the publications of empirical articles that refer to the use of Photobiomodulation for the treatment of Parkinson’s disease with outcomes for voice, speech or swallowing. The following will be described in the table: identifica-

tion of the authors and year of publication, place of publication, DOI, objectives, sample characteristics, the method used with the Photobiomodulation parameters, main findings and the conclusion of the study.

Table 2 - Description of empirical articles on Photobiomodulation as a treatment for voice, speech or swallowing in Parkinson’s disease.

Authors/ year	Journal/ Publication doi	Type of study/ treatment technique	Objective	Photobiomodulation method/ parameters	Main findings	Conclusion	Authors/year
Maloney, R., et al. (2010)	Lasers in Surgery and Medicine DOI:10.1002/Ism.20916	B.EMPIRICAL Clinical trial with eight participants with PD	The aim of this uncontrolled, non-randomized study was to evaluate the improvement of symptoms associated with advanced PD.	Participants received LLLT (PL5000, manufactured by Erchonia Medical Inc.) treatments daily for two weeks. Each participant received treatment of the brainstem, bilateral occipital, parietal, temporal, and frontal lobes, and treatment along the sagittal suture. Symptom severity was recorded using the Visual Analog Scale (VAS) for balance, gait, freezing, cognitive function, rolling over, and speech difficulties before the procedure and at the end of the study, with 10 being the most severe and 0 being no symptoms.	Eight volunteers aged 18 to 80 years with advanced PD participated in an uncontrolled, non-randomized study	Numerical improvement in VAS from baseline to end of study. A statistically significant reduction in VAS scores for gait and cognitive function was observed, with a mean mean change of 1.87 ($p < 0.05$) for gait and a mean decrease of 2.22 ($p < 0.05$) for cognitive function. Additionally, freezing and speech difficulty scores were significantly lower at end of study, with a mean decrease of 1.28 ($p < 0.05$) for freezing and 2.22 ($p < 0.05$) for speech difficulty.	These data suggest that laser therapy may serve as a non-invasive tool for reducing PD symptoms.
Hamilton, C.L., et al. (2019)	Photobiomodulation, Photomedicine, and Laser Surgery DOI: 10.1089/photob.2019.4663	B.EMPIRICAL Clinical trial with six participants with PD	To report the results of six patients with Parkinson’s Disease who used Photobiomodulation (PBM) helmets built by the research group.	“Buckets” coated with light-emitting diodes (LEDs) with wavelengths in the red to near-infrared range (670, 810 and 850nm: n=5) or a homemade intranasal LED device (660nm; n=1) were used 10 minutes for each wavelength, twice a day	Six patients with Parkinson’s disease used PBM therapy. Five patients used helmets and buckets coated with light-emitting diode (LED) devices and one patient used an intranasal LED device. Writing was assessed using ImageJ software, with a 13-word sentence. The words were outlined and the program calculated the area and perimeter of each word.	Patient 1 - PN, 63-year-old man. Signs and symptoms: impairment of fine motor skills and facial movement, difficulty sleeping and swallowing, persistent cough, fatigue, low self-esteem and depression. After 8 weeks, he walked faster, slept better, had more facial animation, more energy, coughed less, swallowed more easily and felt more confident and less depressed. Of the 12 initial signs and symptoms including writing, eleven improved (90%) after PBM, while one remained the same (10%) and none worsened.	In conclusion, more research is needed, both at the basic science and clinical levels, to better understand the impact of PBM on Parkinson’s disease. The explorations of the effects of PBM on patients were encouraging and set a template for future clinical trial development as a viable therapeutic option.



Authors/ year	Journal/ Publication doi	Type of study/ treatment technique	Objective	Photobiomodulation method/ parameters	Main findings	Conclusion	Authors/year
						<p>Pac 2 - MH, 61-year-old male, Signs and symptoms: resting tremor, impaired fine motor skills and facial movements, gait changes, fatigue, apathy, low self-esteem, hesitant speech, and difficulty sleeping. He resumed his usual activities, became more confident, socially interactive, and could think more clearly. Improvements in sleep, speech, and gait became evident, along with a more animated face. Of MH's eleven initial signs and symptoms, including writing, seven improved (*90%) after PBM, while one remained the same (*10%) and none worsened.</p> <p>Pac 3 - CB, a 64-year-old male. Signs and symptoms: slow gait, muscle spasms and stiffness, difficulty swallowing, soft voice, difficulty sleeping and stress, difficult social interaction, had problems tolerating changes in daily routine, his enjoyment of life was limited and his confidence was low. His speech was louder and slightly faster than before. His gait also improved, becoming faster and with greater arm movement. CB's anxiety improved and with it, his ability to tolerate changes in routine and social interactions. Of CB's 14 initial signs and symptoms, including writing, 7 improved (*50%) after PBM, while 7 remained the same (*50%) and none deteriorated.</p> <p>Pac 4 - SS, a 64-year-old man. Signs and symptoms were: resting tremor, gait disturbance, muscle cramps and stiffness, constipation, profuse sweating on exertion, and difficulty swallowing. There was improvement in sweating, muscle cramps, and stiffness. There was no evident improvement in writing, but there was no deterioration during this period. Of the eight main initial signs and symptoms, including his writing, four improved (*55%) after PBM, while three remained the same (*35%) and one worsened (10%).</p>	

Authors/ year	Journal/ Publication doi	Type of study/ treatment technique	Objective	Photobiomodulation method/ parameters	Main findings	Conclusion	Authors/year
						<p>Pac 5 - TU, a 73-year-old man. He was free of the usual parkinsonian signs and symptoms (akinesia and postural instability). His tremor improved, and he had not developed any other parkinsonian signs or symptoms. He did not show any improvement in his writing after PBM, which stabilized and did not worsen.</p> <p>Pac 6 - ML, 75-year-old male. Signs and symptoms: tremor, cogwheel rigidity, impaired facial movements and gait, decreased sense of smell, fatigue, anxiety, slowed thinking, memory impairment, depression, disturbed sleep, Intranasal red light device (660 nm) near the bone covering the brain stem. Improved mood, improved facial movements and energy. Of 16 major signs and symptoms including writing, 7 improved (*45%) after PBM, while 9 remained the same (*55%)</p> <p>- PBM did not target a specific sign or symptom, but had an impact on both motor signs and non-motor symptoms, depending on the patient. In most patients using PBM, the experience improved non-motor symptoms, especially mood, anxiety, sleep, confidence, apathy and fatigue.</p>	

Legend of the acronyms: PD - Parkinson's disease PBM - Photobiomodulation AVC - Stroke TMS - Transcranial Magnetic Stimulation rTMS - Repetitive Transcranial Magnetic Stimulation LSVT - Lee Silverman Voice Treatment LED - Light Emitting Diode

Discussion

From the complete reading of the articles selected for this systematic review, it was possible to observe that no specific studies were found in the databases researched that contemplated the treatment of voice, speech or swallowing in Parkinson's Disease with punctual Photobiomodulation for areas of the muscle groups that involve these functions.

Regarding voice, the RS with the first article included, conceptual or theoretical, showed some authors⁶ during a scientific session of experts, who discuss and refer to the application of Photobiomodulation for voice and consider that the laser used in vocal clinics is low-power, and that its use

does not present bionegative effects on biological tissue when acting on the physiology of the human organism. They also referred to dosimetry and the most appropriate wavelength for clinical application, which is the wavelength in the red laser range (635-700 nanometers) and near-infrared laser (808-1100 nanometers) and dosimetry according to the muscle and expected effect.

The article⁶ also explores and discusses aspects related to vocal rehabilitation in relation to traditional techniques and modern techniques (electrostimulation and photobiomodulation) applied to vocal rehabilitation. Traditional techniques present in their programs, methods or techniques with scientific evidence of better levels of safety and known effects for the procedures performed in the treatment of various voice disorders.

Modern voice therapy techniques already have clinical use and applicability with good results, but there are still few studies indexed in the databases for some populations and more specific vocal disorders. Therefore, it is a promising area to be developed with case studies and randomized or nonrandomized clinical trials to be published. The authors emphasize that there is already high-quality evidence on the effect of Electrostimulation in the treatment of some types of dysphonia⁶.

In Photobiomodulation, the use of low-intensity lasers will act with effects on muscle performance, reducing fatigue, increasing strength, muscle endurance and improving chemical markers⁶. In the neurological population, with post-stroke and PD, the possibility of applying transcranial photobiomodulation is also presented, which improves brain metabolism and neuronal regeneration⁶. It is used not as a sole resource in cases of dysphonia, but as a resource that enhances both the effects of voice treatment and vocal conditioning for voice professionals. The authors conclude that it is necessary to share knowledge in order to develop better evidence with modern techniques through scientific research and vocal clinic⁶.

The use of Photobiomodulation in reducing inflammation, promoting wound healing and preventing tissue damage is already known and well studied⁶. However, for the voice area, we still have little scientific evidence with controlled and randomized studies.

In a meta-analysis, authors⁷ showed that the use of PBM before muscle exercises has a positive influence on the time of execution of motor tasks, with increased resistance and delayed muscle fatigue, with better results when using 5J or 6J per point. These results on muscle function are interesting in individuals with PD, who tend to present fatigue of the vocal and oral motor muscles as the disease progresses.

In another study, the authors⁸, speech-language pathologists at the Center for Laryngeal Surgery and Voice Rehabilitation at Massachusetts General Hospital, verified the efficacy of low-intensity phototherapy (LLLT) in reducing symptoms of vocal fatigue presented after performing the Verdolini Abbott vocal load task, measured by acoustic, aerodynamic and self-reported vocal effort.

The study design was a prospective randomized model, with 16 adult participants without vocal alterations, submitted to the Consensus Auditory-

Perceptual Evaluation of Voice (CAPE-V) and laryngeal endoscopic examination, divided into four groups that had undergone a one-hour vocal load procedure with phrase emission, maintaining vocal amplitude above 75 dB. After intense voice use, participants underwent application of LLLT with infrared wavelength (828nm), LLLT with red wavelength (628nm), with heat or without heat (control) directed to the laryngeal region on the ventral surface of the neck. The following variables were measured: 1- aerodynamic - phonation threshold pressure (PTP), 2- acoustic measurement - relative fundamental frequency (RFF) and 3- self-perception - self-perception assessment scale of inability to produce soft voice (IPSV), recorded at four moments (before, immediately after vocal load, after treatment and one hour after treatment). There was a significant increase in PTP and IPSV values and a decrease in the onset and displacement of relative fundamental frequencies, corroborating the presented vocal dysfunction. The application of red light significantly normalized the combination of PTP, IPSV and RFF measurements compared to other conditions. The authors concluded that red LLLT can normalize objective and subjective measures of vocal fatigue, which establishes the basis and justification for a research area that aims to optimize LLLT wavelength combinations and the overall dose to be applied.

A clinical case study⁹ in the area of swallowing in post-stroke adults presented the use of low-intensity laser therapy associated with traditional speech therapy to improve swallowing triggering and reduce saliva production. The patient was a 54-year-old male, diagnosed with brainstem stroke, with severe oropharyngeal dysphagia and use of gastrostomy (GTT). The following aspects were observed in the speech-language pathology evaluation: absence of spontaneous and commanded swallowing; absent hyolaryngeal elevation; reduced intraoral sensitivity; and presence of sialorrhea. The treatment included conventional speech therapy, with stimulation of swallowing triggering, oral motor control and laryngeal elevation, associated with laser therapy, with daily exercises once a day. Photobiomodulation was applied to the oropharynx and salivary gland regions, at an infrared wavelength (808nm) and a dose of 9J, twice a week with a 72-hour interval between applications, for twelve weeks. The results showed improved intra-oral sensitivity, hyolaryngeal movement, decreased

salivary flow and increased swallowing intention. The authors consider in their conclusion that more robust studies and better scientific evidence need to be carried out to define parameters and verify the efficiency of Photobiomodulation in swallowing changes in this population.

The other three articles included in this SR present Transcranial Photobiomodulation, with application of light in the brain region, showing improvements in several motor and non-motor conditions and symptoms for individuals with PD.

In the other theoretical or conceptual study, the authors¹⁰ conducted a Systematic Review for the treatment of PD using Photobiomodulation, and described the most recent research reported in recent years for the treatment of PD. Different reviews, reports and original articles on general or specific therapies used for patients with PD were verified in the databases. The authors found 350 articles, of which 199 were selected for more detailed reading, of which 197 articles were included in the authors' SR, which distributed and described the articles by area: Physiotherapy (34), Occupational Therapy (10), Speech Therapies (17), Dysphagia (9), Music (10), Hormonal (13), Genetics (17), Stem Cell (16), Light Therapy (17), Deep Brain Stimulation (18), Repetitive Transcranial Magnetic Stimulation (19).

With regard to Speech Therapy, the authors show us that despite the high incidence of speech and voice impairment, only 3 - 4% of patients with PD receive speech therapy, even with the high rate of 89% of individuals affected by PD presenting speech and voice disorders (laryngeal, respiratory and articulatory function disorders).

The studies found for voice and speech treatment highlight the Lee Silverman Voice Treatment (LSVT® LOUD), with evidence and efficacy for the successful treatment of voice and speech disorders in this population. Other studies show a clinical report with improvement in speech, cognition, freezing episodes and gait in 8 patients with PD after 2 weeks of application of photobiomodulation to the head. And another clinical trial with 36 patients with the application of Photobiomodulation using an intranasal device resulted in a 90% improvement in Parkinsonian signs and symptoms. In the end, they concluded that Photobiomodulation therapy is beneficial and promising for use in conjunction with other types of treatments in various areas, due to the lack of side effects and is considered a safe

therapeutic resource with potential neuroprotective action in humans.

In this review, two empirical articles were also selected, one with an experimental research design and the other with the clinical report of six patients regarding motor and non-motor symptoms presented before and after the application of brain Photobiomodulation.

In the article that presented the experimental Clinical Trial, the authors¹¹ monitored the treatment of eight participants with PD, aged between 18 and 80 years, in a non-controlled and non-randomized study with the objective of evaluating the improvement of symptoms of advanced PD. In the experimental method, the participants received Transcranial Photobiomodulation of LLLT with the device (PL5000, from Erchonia Medical), every day for two weeks. The location of the application of the treatment was in the following areas: brainstem, occipital, parietal, temporal and bilateral frontal lobes, and treatment along the sagittal suture. The severity indexes of the symptoms were recorded by the Visual Analog Scale (VAS) for motor and non-motor symptoms (with the value 10 being the most severe and 0 being no symptoms): balance, gait, freezing, cognitive function, rolling in bed and speech difficulties at the beginning and at the end of the treatment. The results showed numerical improvement in the VAS indexes, from baseline to the final results of the study. They observed a reduction in the VAS classification for gait and cognitive function with a mean change of 1.87 ($p < 0.05$) for gait and a mean reduction of 2.22 ($p < 0.05$) for cognitive function. The freezing and speech difficulty classifications obtained significant results with a mean reduction of 1.28 ($p < 0.05$) for freezing and 2.22 ($p < 0.05$) for speech difficulty. The authors concluded that transcranial photobiomodulation can serve as a noninvasive instrument for reducing PD symptoms.

Finally, the article¹² presented the clinical report of six patients, with the objective of reporting the results obtained with transcranial photobiomodulation (PBM) using helmets built by the research team. The research method used bucket-type helmets coated with light-emitting diodes (LEDs) with wavelengths in the red (670, 810nm) to near-infrared (850 nm) range with $n = 5$, or with a homemade intranasal LED device (660nm; $n = 1$). The exposure time to the treatment was 10 minutes for each wavelength, at a frequency

of twice a day. They did not describe the evaluative measure for speech; writing was assessed using the ImageJ software, with a 13-word sentence. As a result, the patients showed improvements in the motor and non-motor symptoms presented, such as improvement in gait, tremors, facial expressions, swallowing and speech difficulties, with better speech intensity. They also showed improvements in mood, sleep and writing. The authors concluded that further research on Photobiomodulation is needed, both at the basic scientific and clinical levels, in order to better understand the impact of PBM on PD. These clinical case reports have established a model for the development of clinical trials with a more robust method and number of participants to obtain scientific evidence and become an accessible therapeutic option for clinical use.

Also regarding the application of Photobiomodulation for voice, authors¹³ suggest that the PBM application protocol before performing vocal exercises enhances its results by stimulating cellular metabolism, ATP production and reducing oxidative stress, favoring more effective phonatory rehabilitation.

In order to increase muscle performance, clinical reasoning should be used in therapeutic programming for the different laryngeal and orofacial muscle structures. Following the following criteria, according to some authors¹³ who describe them: outline the speech therapy objective, select the therapeutic strategy and apply PBM to the extent of the muscle that will be exercised according to the recommended points and dosage. An integrative review was conducted by speech-language pathologists¹⁴ who described the therapeutic effects of photobiomodulation in disorders treated by speech-language pathologists. After analyzing the publications, they identified the distribution in the following areas: Audiology (hearing loss and tinnitus n=3); Orofacial Motricity, with emphasis on Treatment of Temporomandibular Disorders (TMDs) with n=6; Nipple Clefts (n=3) and Facial Paralysis (n=5); and in the areas of Language (n=5) and Voice (n=1). The results suggest that photobiomodulation brings benefits in different disorders treated by speech-language pathologists, but that controlled studies are needed to prove the results and better direct its use by professionals in the area, with the construction of evidence within Speech-Language Pathology.

Another study¹⁵ presented the opinion of speech-language pathologists on the use of Photobiomodulation in vocal clinics. Twenty-nine male and female speech therapists participated in this study and answered a web survey on Google Forms, which contained questions about their training, professional experience and knowledge about Photobiomodulation in the area of voice. They stated that they used PBM to improve their singing (86.2%) and speaking (82.8%) voice performance, and in cases of inflammatory processes in the vocal folds (79.3%). The most commonly used wavelength was 808 – 830nm (37.9%) and 660/808nm simultaneously (37.9%), with a dose of 3-5 J per point for patients with inflammatory processes in the vocal folds (51.7%) and 6-9 J (44.8%) per point for patients whose goal was voice improvement/conditioning. The authors concluded that the professionals demonstrated knowledge and training in PBM and its applicability to the area of voice. Given what was presented in this SR about the use of Photobiomodulation in speech, voice and swallowing disorders in individuals with Parkinson's, it was possible to observe that only four studies indexed in the databases reported results for the treatment of these speech-language pathology aspects using Photobiomodulation resources, including transcranial Photobiomodulation. Thus, the importance of new studies that evaluate its efficacy and evidence to prove the benefits and results already found in clinical practice for this population is shown.

Given what was presented in this SR about the use of Photobiomodulation in speech, voice and swallowing disorders in individuals with Parkinson's, it was possible to observe that only four studies indexed in the databases reported results for the treatment of these speech-language pathology aspects using Photobiomodulation resources, including transcranial Photobiomodulation. Thus, the importance of new studies that evaluate its efficacy and evidence to prove the benefits and results already found in clinical practice for this population is shown.

Conclusion

Implications for Research

The diversity of laryngeal, speech and swallowing alterations requires us to conduct controlled studies on the use of Photobiomodulation, in order

to promote benefits, with safety and efficacy of its effects on the mucosa or muscle altered in the underlying pathology to be rehabilitated.

Implications for Practice

Therefore, randomized controlled clinical trials with a greater number of participating patients are necessary to enhance evidence-based clinical practice, even though clinically we already have good results in speech therapy for voice, speech and swallowing with the application of Photobiomodulation for Parkinson's Disease.

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