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Review articles

Therapeutic effects of photobiomodulation in the speech-language-hearing clinic: an integrative literature review

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ABSTRACT

Purpose: to conduct a literature review on the therapeutic effects of photobiomodulation applicable to speech-language-hearing therapy.

Methods: the databases searched were the Cochrane Library, Virtual Health Library, Medical Literature Analysis and Retrieval System Online (MEDLINE) via PubMed, and Web of Science/ISI.The selected articles were original ones whose abstracts were available and that evaluated the therapeutic effect of photobiomodulation in situations related to speech-language-hearing practice.

Results: the sample comprised 23 articles, most of them being indexed in PubMed. The fields of health with the largest number of publications were Physical Therapy and Medicine. The sample size ranged from1 to 99 people, aged 15 to 77 years, and the most applied wavelength was the infrared one. Most of the studies had positive photobiomodulation application results – although in a few publications the effects of this treatment modality were assessed in a combination with rehabilitation exercises.

Conclusion: photobiomodulation benefits different disorders treated by speech-language-hearing therapists, however, there is a broad methodological diversity, lacking specific protocols for the ideal dosimetry for each disorder.

Keywords: Audiology; Speech, Language and Hearing Sciences; Stomatognathic System; Low-Level Light Therapy; Voice

INTRODUCTION

Low-level laser (LLL) therapy to modulate cell and tissue physiology can be applied from light sources such as a light-emitting diode (LED) and low-level light amplification by stimulated emission of radiation (laser)[1].

Photobiomodulation (PBM) is the application of light to a biological system to induce a photochemical process – especially in the mitochondria, stimulating the production of energy as adenosine triphosphate (ATP)[2]. Hence, cell metabolism is increased, producing effects such as analgesia[3], tissue regeneration, wound scarring[4], decreased muscle fatigue[5], and so forth. Besides these, evidence from the application of neuromodulation to different regions of the nervous system points to an increase in brain perfusion, resulting in cognitive and behavioral improvement in neurological diseases such as dementia, traumatic conditions, and Parkinson's disease, besides possible cognitive improvements in healthy people[6].

Speech-language-hearing therapists are increasingly interested in joining the group of professionals who use PBM, as it is a noninvasive and nontoxic therapeutic resource with promising results. Some studies have recently evaluated its results in speech-language-hearing rehabilitation in the fields ofAudiology and Oral-Motor Function and observed, respectively, reduced tinnitus[7]and improved electrical activity in the orbicularis oris muscle[8].

Despite the scarcity of studies in speech-language-hearing pathology, the application of PBM in disorders also treated by speech-language-hearing therapists has already been reported in the literature. In Audiology, there are studies on tinnitus[9,10] and hearing loss[11]. In Language, there is research on the use of neuromodulation in healthy people[12] andischemic[13], neurodegenerative[13,14], and traumatic diseases[15] reporting improved naming capacity in aphasic patients, as well as improvements in other cognitive skills[16]. In Oral-Motor Function, which concentrates a large part of the research, temporomandibular disorder (TMD)[17-22], nipple fissures[23-25], and facial palsy (FP)[26-30] treatment is highlighted. Lastly, in the field of Voice, a study has been conducted on vocal fatigue[31].

Even though PBM has been used in the speech-language-hearing clinic, there is no robust evidence of its effects as a therapeutic technique, considering clinical aspects such as 1) most effective application (before, during, after exercises); 2) wavelength to be used; 3) application time; and 4) dosimetric parameters. Therefore, speech-language-hearing interventions with PBM application need to be standardized, using structured clinical protocols for the rehabilitation of different clinical conditions.

Given the above, this study aimed to conduct a literature review on the PBM therapeutic effects applicable to speech-language-hearing therapy.

METHODS

Research strategies

This is an integrative literature review. The studies were selected based on the following steps: development of the research question, search in the literature, and critical analysis of the studies[32].

The following research question guided the search on which the review was based: What are the therapeutic effects of PBM on disorders treated by speech-language-hearing therapists?

The articles were selected from the Cochrane Library, Virtual Health Library (VHL), Medical Literature Analysis and Retrieval System Online (MEDLINE) via PubMed, and Web of Science/ISI databases. The descriptors used were "Audiology", "Speech, Language and Hearing Sciences", "Stomatognathic System", "Low-Level Light Therapy", and "Voice", and their combinationsin English, Portuguese, and Spanish. The other speech-language-hearing specializations, as they are not descriptors, were used in the search as free terms.

Selection criteria

After finding the studies, they were screened by title and abstract. This stage was independently carried out by two speech-language-hearing evaluators. Considering the inclusion and exclusion criteria,23 articles were selected to be read in full.

Original articles whose full text was available, published between 2010 and 2020, assessing the therapeutic effects of PBM in situations applicable to speech-language-hearing therapy were selected.

Duplicated articles, found in more than one database, were excluded, as well as those evaluating only analgesia or other PBM effects, not considering functional aspects, studies in animals, and ongoing research, whose final results had not yet been published.

Hence, the sample comprised 23 articles, of which 19 were inMEDLINE/ PubMed and four, inVHL (Figure 1).

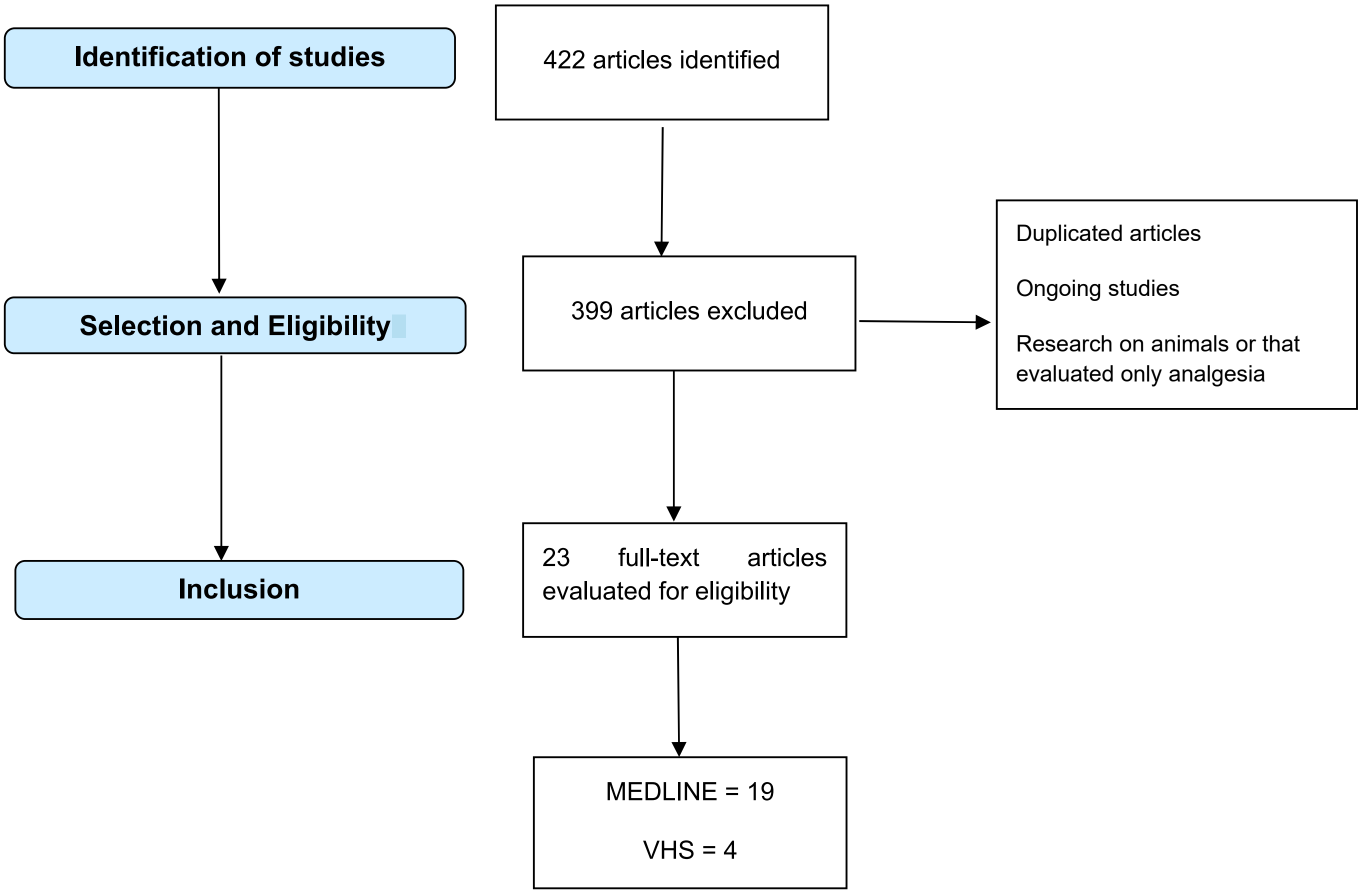


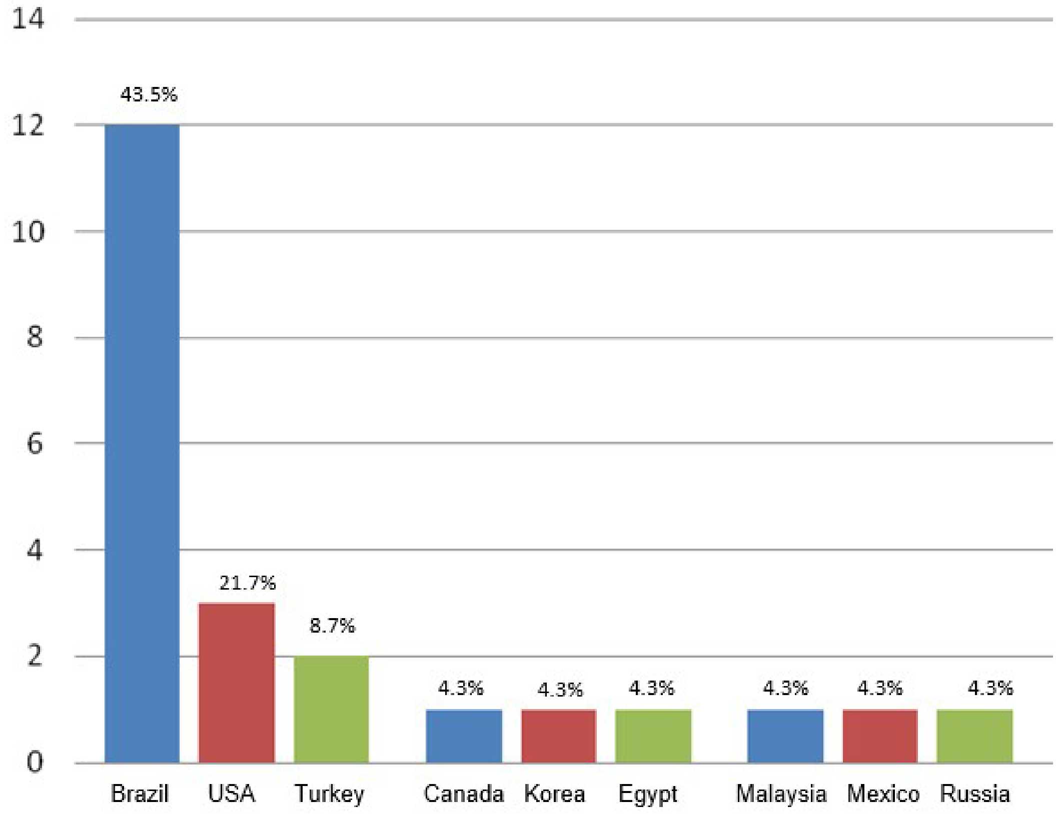
Figure 1. Selection and analysis of the articles

The texts were fully read and analyzed considering year and place of publication, language, first author's professional education, study design, classification of the level of scientific evidence by the Oxford scale[33], objectives, sample, types of PBM, wavelength, number of sessions, areas of application, energy per point, time of application, and outcomes in each identified theme. The Oxford scale[33] classifies, particularly, the study designs; the evidence is classified in levels, from best to worst, as 1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b, 4, and 5.

LITERATURE REVIEW

Based on the methodology applied, 23 references were selected – 10 national and 13 international articles. Regarding language, 21 articles had been published in English (91.3%), one in Portuguese (4.35%), and one in Spanish (4.35%). Brazil led the number of articles, followed by the United States (Figure 2).

As for the year, a larger number of publications were from 2012 and 2019 (Figure 3).



Caption: USA – United States of America

Figure 2. Number of publications per country

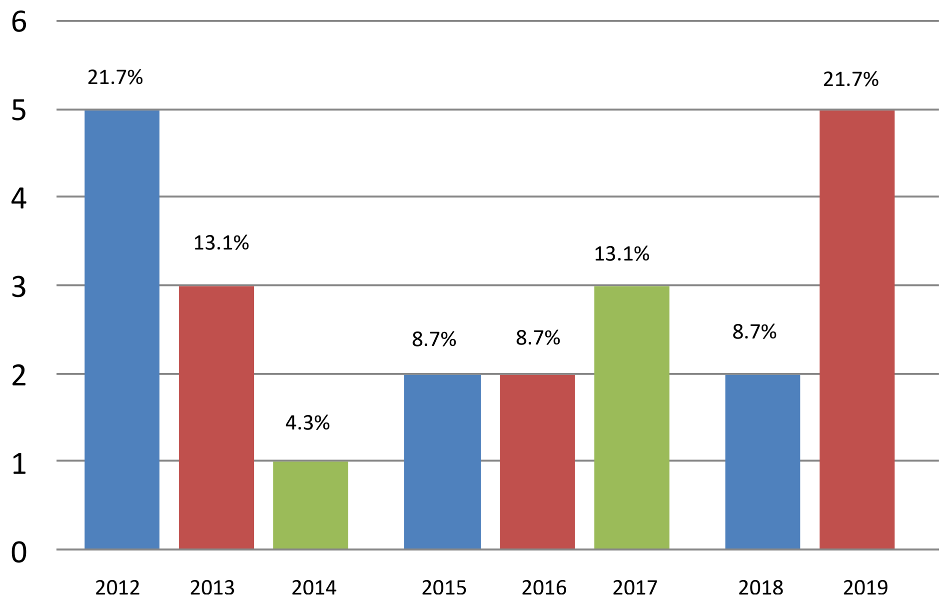


Figure 3. Number of publications per year

Concerning the first author's professional education, six (26.1%) were physical therapists, six (26.1%) were physicians, four (17.4%) were dentists, two (8.7%) were nurses, two (8.7%) were speech-language-hearing therapists, one (4.3%) was a psychologist, and two (8.7%) studies did not include this information.

Regarding the research design, there were 17 (73.9%) clinical trials (level of evidence: 2B) and six (26.1%) descriptive studies (level of evidence: 4). Of the selected clinical trials, 12 studies (70.5%) useda placebo, andseven (41.1%) described the blinding of the evaluators, thepatients, or both.

The sample size ranged from one to 99 people, aged 15 to 77 years. Only one article was conducted with children.

Concerning the type of PBM, 16 articles usedlaser (69.6%), six used LED (26.1%), and one (4.3%) did not describe it. The infrared wavelength was applied in 13 pieces of research (56.5%), the red one was applied in five (21.7%), and a combination of both was applied in four publications (17.4%).

The analysis of the publications led to the identification of the following main themes: Therapeutic PBM effects in Audiology, highlighting publications on hearing loss and tinnitus (n=3); in Oral-Motor Function, highlighting the treatment of TMD (n=6), nipple fissures (n=3), and facial palsy (n=5); and in Language (n=5) and Voice (n=1).

The results were described separately, by fields of specialization (Figures 4 to 9).

Reference	Place of publication/ Language/ First author's professional training	Study design/ Level of evidence	Objectives/Sample	Type ofphotobiomodulation/ Wavelength/Number of sessions	Areas of application/Energy per point/Time of application	Outcomes
Ngao et al., 2013[9]	Malaysia English Medicine	Randomized, controlled clinical trial, double-blind with placebo. 2B	To examine the effectiveness of transmeatal LLL stimulation to treat tinnitus in 43 patients, mean age 58 years. G1 – laser treatment G2– placebo device for use and oral medication– 24 milligrams, twice a day.	Laser Red 10 weeks (daily)	Laser through the EAM 5 mW of power 20 minutes	The transmeatal LLL stimulation did not prove to be effective as a therapeutic measure to treat tinnitus.
Choi et al., 2019[10]	Korea English Medicine	Randomized, controlled clinical trial, blind with placebo. 2B	To assess the effectiveness and safety of LLL to treat chronic unilateral tinnitus in 38 participants with cochlear dysfunction, mean age 55.5 years. G1 – laser group G2 – placebo group	Laser Infrared 10 sessions	Irradiation through the tympanic membrane 120 J 20 minutes a day	The tinnitus duration decreased significantly in the group treated with laser.
Goodman et al., 2019[11]	United States English Training not described	Randomized, controlled clinical trial, double-blind with placebo. 2B	To determine whether LLL improves hearing, speech comprehension, and cochlear function in 30 adults with hearing loss, mean age 52.8 years. G1- laser G2- placebo G3- control	Laser Red 3 sessions	Temporomandibular region and EAM Dosimetry not described 4 minutes	No significant difference was found between the groups in any of the hearing tests.

Captions: G – group; J – Joules; J/cm2 – Joules per square centimeters; LLL –low-level laser; EAM – external acoustic meatus; mW – milliwatts

Figure 4. Therapeutic effects of photobiomodulation related to the field of Audiology (treatment of hearing loss and tinnitus)

Reference	Place of publication/ Language/ First author's professional training	Study design/ Level of evidence	Objectives/Sample	Type ofphotobiomodulation/ Wavelength/Number of sessions	Areas of application/Energy per point/Time of application	Outcomes
Blanco et al., 2015[12]	United States English Psychology	Controlled clinical trial with placebo 2B	To evaluate the effect of transcranial stimulation on the executive function of 30 healthy participants, mean 20.4 years (active and placebo groups). G1 – photobiomodulation group G2 – placebo group	Laser Infrared 8 sessions	Prefrontal cortex 60 J/cm2 4 minutes	Transcranial stimulation can improve executive functioning in healthy young adults.
Maksimovich et al., 2015[13]	Russia English Medicine	Controlled clinical trial 2B	To evaluate the use of photobiomodulation to treatischemic and neurodegenerative lesions in 37 patients with BD (mean 78 years) and 62 with VP (mean 77 years). G1 – photobiomodulation group G2 – conservative treatment	Laser Red 2 sessions/year (8 years)	Intravascular laser 29 to 196 J per session 1200 to 2400 seconds/session	The blood supply and neurogenesis recovered, and the mental and cognitive functions, movement disorders, and level of dementia improved in patients with BD and VP treated with photobiomodulation.
Saltmarche et al., 2017[14]	Canada English Medicine	Case series 4	To investigate whether 5 patients with AD had cognitive and behavioral improvements when treated with transcranial and intranasal stimulation (mean 77.9 years).	LED Infrared 12 sessions	Bilateral prefrontal cortex, posterior cingulate gyrus, angular gyrus, and hippocampus 10.65 to 24.6 J 20-25 minutes/ session	The cognition and functioning improved during the active treatment.
Hipskind et al., 2019[15]	United States English Medicine	Case series 4	To evaluate the effects of transcranial stimulation on neuropsychological aspects and blood flow in 12 patients with chronic TBI (mean 41.5 years).	LED Red Infrared 18 sessions	A device designed to cover the whole skull. 3994 J per treatment 20 minutes	The photobiomodulation helped increase brain and blood flow, and the neuropsychological scores.
Naeser et al., 2019[16]	United States English Medicine	Case series 4	To examine the effects of four different transcranial stimulation protocols on the naming capacity of 6 aphasic patients after left hemisphere stroke (aged 46 to 69 years).	LED Red Infrared 18 sessions	Frontal, temporal, parietal cortex 13 to 39 J/cm2 12 to 36 minutes/ session	There was a better naming capacity with unilateral left hemisphere transcranial stimulation.

Captions: AD – Alzheimer dementia; BD – Binswanger's disease; J – Joules; J/cm2 – Joules per square centimeters; LED –light-emitting diode; VP – vascular parkinsonism; TBI – traumatic brain injury

Figure 5. Therapeutic effects of photobiomodulation related to the field of Language

Reference	Place of publication/ Language/ / First author's professional training	Study design/ Level of evidence	Objectives/Sample	Type ofphotobiomodulation/ Wavelength/Number of sessions	Areas of application/Energy per point/Time of application	Outcomes
Gokçen-Rohlig et al., 2013[17]	Turkey English Dentistry	Controlled clinical trial with placebo 2B	To evaluate LLL effects on occlusal contact, occlusal pressure, and bite strength in 20 participants with TMD, mean age 33.1 years. G1 – laser group G2 – placebo group	Laser Infrared 10 sessions	Application on the trigger points (masticatory musculature) 3 J/cm2 (2 millimeters away)10 seconds	The mandibular movements improved in all the patients, and their pain eased. However, no significant change was found in maximum bite strength, contact area, or occlusal pressure.
De Moraes et al., 2014 [18]	Brazil English Dentistry	Controlled clinical trial with placebo 2B	To investigate OMT effects on masticatory performance, and pain threshold and intensity in 20 subjects with myofascial pain, mean 27.7 years. G1 – laser group G2 – placebo group	Laser Infrared 8 sessions	5 points on the masseter and the temporal 1.9 J per point (1cm away) 19 seconds	The pain eased in both groups. LLL improved the performance of the masticatory muscles.
Borges et al., 2016[19]	Brazil English Physical Therapy	Randomized, controlled clinical trial, double-blind with placebo 2B	To evaluate different dosimetry to treat TMD in 44 subjects 15 to 59 years old. G1 – 8J/cm2; G2 – 60 J/cm2; G3 – 105 J/cm2; G4 – control	Laser Infrared 10 sessions	4 points (preauricular region and EAM) 0.96 to 12.64 J per point 15 seconds in contact with the surface	The pain eased in tested dosages. However, only the dosage of 8 J/ cm2was effective in mandibular opening.
Melchior et al., 2016[20]	Brazil English Speech-Language-Hearing Pathology	Descriptive 4	To evaluate OMST effect after analgesia with LLL to treat 5 women with TMD, aged 50 to 61 years.	Not evaluated	Not evaluated	Post-analgesia OMT with LLL balanced the oral-motor functions and decreased TMD signs and symptoms.
Brochado et al., 2018[21]	Brazil English Physical Therapy	Randomized, controlled clinical trial 2B	To compare the effectiveness of photobiomodulation and manual therapy, both alone and in combination, to treat 51 people with TMD, aged 21 to 77 years. G1 – photobiomodulation group; G2 – manual therapy; G3 – combined therapy	Laser Infrared 12 sessions	12 points on the TMJ and 7 on the temporal, masseter, and medial pterygoid muscles. 4 J per point 40 seconds with located contact	The pain eased, and the mandibular function and psychosocial aspects improved inboth treatments, with no increase in effectiveness in combined therapies.
Herpich et al., 2018[22]	Brazil English Physical Therapy	Randomized, controlled clinical trial, double-blind with placebo 2B	To evaluate the LLL effects on pain, mandibular movement, and electrical activity of the masseter and temporal muscles in 60 women 18 to 40 years old. G1 – 2.62 J; G2– 5.24 J; G3 – 7.86 J; G4 - control	LED Red Infrared 1 session	2 points on the masseter 3 points on the temporal 2.62 J to 7.86 J 20 to 60 seconds of application	The pain eased significantlywith different phototherapy dosages, with no differences in mandibular movement or electrical activity of the muscles.

Captions: TMJ – temporomandibular joint; cm – centimeters; TMD – temporomandibular disorder; J – Joules; J/cm2 – Joules per square centimeters; LLL – low-level laser; LED – light-emitting diode;EAM – external acoustic meatus; OMT – orofacial manual therapy; OMST – orofacial myofunctional speech-language-hearing therapy

Figure 6. Therapeutic effects of photobiomodulation related to the field of Oral-Motor Functions (treatment of temporomandibular disorders)

Reference	Place of publication/ Language/ / First author's professional training	Study design/ Level of evidence	Objectives/Sample	Type ofphotobiomodulation/ Wavelength/Number of sessions	Areas of application/Energy per point/Time of application	Outcomes
Coca et al., 2012[23]	Brazil English Nursing	Randomized, controlled clinical trial, triple-blind 2B	To investigate the effectiveness of LLL to treat nipple pain due to breastfeeding in 59 women 20 to 30 years old. G1 – laser group G2 – placebo group	Laser Red 3 sessions	Contact application on the affected breast. 0.6 J per point 5 seconds	The pain intensity eased 24 hours after the first intervention, besides the lower pain levels in relation to the control, which allowed for exclusive breastfeeding.
Chaves et al., 2012[24]	Brazil English Physical Therapy	Randomized, controlled clinical trial, double-blind, with placebo 2B	To evaluate the effectiveness of LED phototherapy to treat nipple trauma in 16 breastfeeding women, mean age 31.5 years. G1 – Nipple care + breastfeeding techniques + active LED. G2 – Nipple care + breastfeeding techniques + placebo LED.	LED Infrared 12 sessions	Location not precisely described 4 J/cm2 79 seconds	The nipple lesion area was reduced in both groups. However, with a significant difference in scarring and eased pain only in the experimental group.
Camargo et al., 2019[25]	Brazil English Nursing	Randomized, controlled clinical trialwith placebo 2B	To evaluate the effects of a single LLL application and its side effects on 80 women, mean age 26 years, with nipple pain when breastfeeding. G1 – laser group G2 – placebo group	Laser Red Single session	Application on the center of the lesion 2 J in located and perpendicular contact 20 seconds	The single-application laser protocol was not effective to ease the pain in women with hurt nipples; 36% reported a tingling sensation.

Captions: G – group; J – Joules; J/cm2 – Joules per square centimeters; LLL – low-level laser; LED – light-emitting diode

Figure 7. Therapeutic effects of photobiomodulation related to the field of Oral-Motor Functions (treatment of nipple fissures)

Reference	Place of publication/ Language/ / First author's professional training	Study design/ Level of evidence	Objectives/Sample	Type ofphotobiomodulation/ Wavelength/Number of sessions	Areas of application/ Energy per point/Time of application	Outcomes
Alfaya et al., 2012[26]	Brazil Portuguese Dentistry	Case report 4	To report the clinical case of a 29-year-old male patient with BP and TMD (with an occlusal splint, laser, pharmacotherapy, andspeech therapy).	Laser Infrared 13 sessions	27 points (facial nerve path) 4 J/cm2 per point	The painful symptomatology eased, though without full motor recovery of the facial nerve.
Fontana et al., 2012[27]	Brazil English Dentistry	Case report 4	To apply LLL and speed the recovery process of a 3-year-old patient with BP.	Laser Red Infrared 11 sessions	Maximum of 80 points 17.5 J/cm2 (direct contact, facial nerve path) 10 seconds	The movements of the face fully recovered after 11 LLL sessions.
Maciaz Hernandes et al., 2012[28]	Mexico Spanish Physical Therapy	Randomized, controlled clinical trial with placebo 2B	To demonstrate the use of laser as a complementary treatment in facial nerve recovery in 21 people, mean age 43 years. G1 – placebo+thermal therapy and facial exercises G2 – Conventional rehabilitating treatment +placebo laser	Laser Infrared 15 sessions	Points not described 20J/cm2 (facial nerve path, perpendicular and localized technique) Time not described	Both groups improved muscle strength (94.84% laser group; 87.83% control group).
Alayat et al., 2013[29]	Egypt English Physical Therapy	Randomized, controlled clinical trial with placebo 2B	To evaluate and compare the effects of low- and high-level laser in BP treatment in 48 people, mean age 43 years. G1 – high-level laser + facial exercises +massage G2 – LLL+ exercises + massage G3 – placebo+exercise + massage	Laser Infrared 18 sessions	8 points (facial nerve path) 80 J per session 7 seconds (high-level) 2 minutes and 5 seconds (low-level)	Both high- and low-level laser helped in BP recovery, though LLL was more effective.
Ordahan et al., 2017[30]	Turkey English Training not described	Randomized, controlled clinical trial 2B	To evaluate the effects of laser therapy on BP in 46 people, mean age 45 years. G1 – facial exercises G2 – laser+ facial exercises	Laser Infrared 18 sessions	8 points (facial nerve path) 10 J/cm2 per point 2 minutes	The combined LLL and exercise treatments presented a better facial recovery than exercises alone.

Captions: TMD – temporomandibular disorder; G – group; J – Joules; J/cm2 – Joules per square centimeters; LLL – low-level laser; BP – Bell's palsy

Figure 8. Therapeutic effects of photobiomodulation related to the field of Oral-Motor Functions (treatment offacial palsy)

Reference	Place of publication/ Language/ / First author's professional training	Study design/ Level of evidence	Objectives/Sample	Type ofphotobiomodulation/ Wavelength/Number of sessions	Areas of application/Energy per point/Time of application	Outcomes
Kagan et al., 2017[31]	United States English Speech-Language-Hearing Pathology	Randomized clinical trial 2B	To investigate the effectiveness of LLL in mitigating vocal fatigue symptoms caused by an overloaded vocal task measured with acoustic, aerodynamic, and self-reported vocal effort in 16 vocally healthy adults 22 to 35 years old. G1 – application of infrared laser G2 – application of red laser G3 (control) – application of heat G4 (control) – neither heat nor LLL applied	LED Red Infrared 1 session	Ventral neck surface Energy applied below the international safety limits (1/20) 20 minutes	The red light proved to be more effective in all the evaluated parameter markers. There were better responses one hour after the treatment.

Captions: G – group; LLL – low-level laser; LED – light-emitting diode

Figure 9. Therapeutic effects of photobiomodulation related to the field of Voice

Therapeutic PBM effects in Audiology

In the field of Audiology, PBM has been used in treatments for various decades, mainly to treat tinnitus[9,10].

In the two studies found, the number of treatment sessions ranged from three to 10[9-11], and two studies used the red wavelength[9,11]. The areas of application were the external acoustic meatus and tympanic membrane, and the application time ranged from 4 to 20 minutes.

The LLL transmeatal stimulation in 43 patients was not an effective therapeutic means to treat tinnitus[9]. In another research, though, the tinnitus duration decreased significantly in the group treated with laser[10]. Studies are scarce in the national literature, as well as treatment protocols. The discrepancy in results may be due to the small sample and the different types of treatment protocols used. These factors hinder the adequate comparison between the results.

Although one piece of research did not reveal any improvement in hearing, speech comprehension, or cochlear function after applying LLL[11], there is evidence proving the increase in ATP production after PBM[2] – which could sustain the theory of beneficial effects in cases of hearing loss.

Therapeutic PBM effects in Language

Five selected studies evaluated the effects of transcranial neurostimulation in both healthy participants[12] (with evidenced improvement in executive function) and cases of lesions in the nervous system from ischemic[13], neurodegenerative[14], and traumatic factors[15]. One study demonstrated improvementin the linguistic capacity of aphasic patients after neurostimulation[16].

The dosimetry ranged from 10.65 to 196 Joules (J) per session; the treatment lasted 8 to 18 sessions; the stimulation time was 4 to 36 minutes; both laser and LED were used – most of the time, infrared wavelength. Transcranial laser stimulation is a new, safe, and noninvasive brain PBM method that has benefits such as increased blood flow, decreased edema, neuroprotection, neurogenesis, and an anti-inflammatory effect[5]. The frontal cortex was stimulated in most of the studies, while there was no association between language exercises and neurostimulation in any of them.

One study revealed an improvement in the neuropsychological scores in traumatic brain lesions after transcranial stimulation[15]. There is a growing need for rehabilitation strategies, as the different cognitive rehabilitation techniques and combinations can be useful to treat various cognitive deficits due to traumas in the nervous system[34].

Research with PBM in cases of ischemic, neurodegenerative, and traumatic diseases show cognitive improvement, probably due to factors such as increased brain blood flow and neurogenesis[5].

The ideal energy wavelength, duration, dosage, flow, and density for each treatment have not yet been established, and it is not clear how long the neurostimulation effects last, although the evidence suggests that transcranial stimulation is an important medical tool to treat cognitive deterioration.

Therapeutic PBM effects in Oral-Motor Function

TMD treatment

The studies presented various objectives, such as assessment of bite strength[17], masticatory performance and analgesia[18], effects of different dosimetry on the treatment of TMD[19] in oral-motor function[20], comparison of PBM effects, either alone or in combination with manual therapy[21], and impact on the amplitude of mandibular movements[22].

In only one study, electromyography was used to assess muscle electrical activity[22]. In four studies, the interventions were applied to experimental and placebo groups[17-19,23]. In one, the PBM effects were combined with manual therapy, which did not reveal any increase in therapy effectiveness when the treatment modalities were combined[21]. These data agree with a study that demonstrated eased pain and improved masticatory function and orofacial myofunctional conditions with myofunctional therapy, both alone and in combination with laser therapy[8]. Another research, on the other hand, did not evidence any changes in mandibular movements or electrical activity of the masticatory muscles[22] with laser application. The lack of a standardized protocol may contribute to discrepancies in the findings, as the dosimetry, time of exposure, wavelength, irradiation points, and the number of applications are important factors to determine the use of LLL therapy on damaged tissues.

In the last research carried out by speech-language-hearing pathologists[20], it was found that speech-language-hearing therapy conducted after analgesia with LLL balanced the oral-motor functions in TMD. However, that therapy began one month after finishing LLL therapy, which was not described.

The number of sessions ranged from six to 10, and the most used wavelength was the infrared. Five studies applied laser, and the main application points were the masticatory musculature, temporomandibular joint, and external acoustic meatus[17-21]. The dosimetry ranged from 0.96 to 12.64 J, and the application time per point ranged from 10 to 60 seconds.

Thus, the evidence does not make it possible to establish an application dosage window, and the lack of consensus on the measures limits the conclusions about PBM.

Therapeutic PBM effects in Oral-Motor Function

Nipple fissure treatment

In the present study, three selected pieces of research evaluated the PBM effects on the treatment of nipple fissures due to breastfeeding. The number of sessions ranged from 1 to 12, the applied energy ranged from 0.6 to 2 J per point, and the application time ranged from 5 to 79 seconds on the affected region of the breast.

The selected articles aimed to evaluate the scarring and the eased pain when breastfeeding[24-26]; two of them evidenced positive effects when using either LED or laser in the red and infrared wavelengths[23,24]. A study that did not identify any improvement conducted only one session, which may have influenced the results[25]. Research shows positive PBM effects on scarring and on the reduction of the inflammatory process, even after a surgical procedure[3]. The scarring effect may be due to physiological processes that take place when ATP production increases[2] in the cells, which stimulates mitosis and metabolism, and consequently increases the endothelium cell proliferation, angiogenesis, and speeds tissue reparation.

The literature lacks randomized controlled clinical trials that objectively assess whether the area with nipple fissures has decreased, as well as the ideal dosimetry and time of treatment to achieve the desired results.

Therapeutic PBM effects in Oral-Motor Function

Facial palsy treatment

Five selected publications approached the use of PBM on peripheral facial palsy, four of which were cases of Bell's palsy (BP). In idiopathic facial palsy or BP, there may be functional sequelae such as oral incompetence, contractures, dysgeusia, synkinesis, and hemifacial spasms[35].

Regarding the study designs, there were two case reports[26,27] and three clinical trials[28-30]. Only one study was conducted with children[28]. The LLL has been proposed as a painless, noninvasive treatment modality, with no side effects, and with faster clinical improvement[30].

The infrared laser was the most used, whereas the irradiated points, the dosage, laser contact application time, and the number of sessions varied widely between the studies. The number of stimulated points ranged from eight to 80, the energy density ranged from 4 to 20 J/cm^2, the irradiation time ranged from 10 seconds to 2.7 minutes, and there was an average of 11 to 18 treatment sessions.

A study conducted with 48 patients with BP demonstrated that low- and high-level laser combined with orofacial exercises is more effective in treatment than exercises alone[29]. This corroborates another research with 46 subjects which also presented better results when applying combined treatments[30]. Intervention can be enhanced by applying LLL, as it speeds nerve regeneration acting as a cell stimulant and connective tissue modulator[36].

A systematic review with meta-analysis evaluated pre-exercise PBM effects on large muscle groups and evidenced that laser therapy is effective to improve the exercise capacity of skeletal muscles[4].

Two studies did not present full motor recovery[26] or any difference between the experimental and placebo groups[28]. The results may vary when different dosages or application techniques are used – as there is no consensus in the literature concerning dosage, application time, and the irradiation points in peripheral facial palsy procedures[37].

Even though the studies evaluated facial nerve recovery using orofacial exercises combined with laser therapy, the first author was not a speech-language-hearing therapist in any of them.

Therefore, laser can be used as a complementary therapy for facial palsy recovery. It should be highlighted, though, that the literature lacks great randomized controlled clinical trials that consider the patients' characteristics – such as their skin color and condition, whether it is acute, subacute, or chronic–, besides the ideal stimulation window, in order to prove the effectiveness of this therapeutic resource.

Therapeutic PBM effects in Voice

There is a scarcity of studies on the effectiveness of PBM to treat voice disorders. Only one study assessed the effectiveness of low-level light therapy with LED irradiation to treat vocal fatigue in 16 vocally healthy people[31].The results showed that the red light proved to be more effective in the acoustic, aerodynamic, and auditory-perceptual measures, with better responses one hour after the procedure. Recent research has demonstrated beneficial PBM effects on muscle fatigue based on the metabolic and photochemical effects, which help increase cell energy[5]. Also, there is evidence of greater proliferation and migration of epithelial cells of the human vocal fold in culture, as well as increased expression of some genes involved in tissue scarring, after PBM application[38].

Further studies are necessary to establish the ideal light dosages, the best effectiveness of the wavelengths (whether alone or in combination), and the time when to apply the dosages (before, during, or after the vocal technique) to furnish resistance to fatigue, speed recovery, or improve muscle performance.

CONCLUSION

This integrative review identified pieces of research that approached therapeutic PBM effects in situations related to speech-language-hearing practice. There is a concentration of studies on Oral-Motor Function, particularly on TMD treatment. There are also studies in the fields of Audiology, Language, and Voice, although in almost all of them the first author's professional training was in some other field of health, especially Physical Therapy, Medicine, and Dentistry.

The results suggest that PBM benefits different disorders treated by speech-language-hearing therapists. However, considering the diversity of methodologies, scarcity of studies conducted by professionals of the field, lack of specific and standardized protocols for the ideal dosimetry for each disorder, the data in the literature are controversial, with questionable evidence of the application of this resource.

Hence, it is suggested that randomized controlled clinical trials be conducted by speech-language-hearing therapists of different fields of practice, with a detailed description of the dosimetric parameters and speech-language-hearing techniques used in the procedures, to prove the results, better guide their use by professionals of the field, and establish evidence within the Speech-Language-Hearing Sciences.

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