Literature Review

https://doi.org/10.1590/2317-6431-2021-2552

Audiology Communication Research
ISSN 2317-6431

The use of photobiomodulation for the muscles of head and neck: an integrative review

O uso da fotobiomodulação nos músculo da cabeça e pescoço: revisão integrativa da literatura

Sara Loureiro de Souza Ferreira[1], *Daniele Andrade da Cunha*[1], *Aline Natalia Simões de Almeida*[1], *Maria Deluana da Cunha*[1], *Roberto Sávio de Assunção Bastos*[2], *Hilton Justino da Silva*[1]

ABSTRACT

Purpose: To carry out an integrative review of the literature on the use of photobiomodulation (PBM) for the head and neck muscles. **Research strategy**: The research took place between June/2019 and March/2021, in the following databases: PubMed, Scopus, Web of Science, LILACS, and SciELO. The MeSH used were Low-Level Light Therapy, Phototherapy, Masseter Muscle, Masticatory Muscles, Tongue, Palate, Mouth, Neck Muscles, and Facial Muscles in English and Portuguese. No limitation was imposed on the year and language of publication. **Selection criteria**: studies that answered the guiding question: what is the use of photobiomodulation to the head and neck muscles?. **Results**: 2857 articles were found, of which 102 were selected for full reading, 52 of those were excluded, giving a total of 50 articles included. The included publications date from 2003 to 2020. Brazil was the country that most published on the topic. With regard to the objectives, 82% of the studies aimed to investigate the analgesic effect of PBM, of these, 50% were related to articular or muscular temporomandibular disorders (TMD). The heterogeneity of the studies makes it impossible to define the dose protocols. **Conclusion**: PBM has been applied to the head and neck muscles mainly for the treatment of pain caused by TMD. There is no treatment protocol to define the doses to be used, due the heterogeneity of the methodologies applied and results found.

Keywords: Low-level laser therapy; Masseter muscle; Facial muscles; Muscles of the neck; Temporomandibular joint dysfunction syndrome

RESUMO

Objetivos: realizar uma revisão integrativa da literatura sobre o uso da fotobiomodulação nos músculos de cabeça e pescoço. **Estratégia de pesquisa**: As buscar foram realizadas nas bases de dados: PubMed, Scopus, Web of Science, LILACS e SciELO. A pesquisa ocorreu entre junho de 2019 e março de 2021. Os descritores utilizados foram Terapia com Luz de Baixa Intensidade, Fototerapia, Músculo Masseter, Músculos Mastigatórios, Língua, Palato, Boca, Pescoço, Músculos do Pescoço, Músculos Faciais e seus respectivos termos em inglês. Não houve limitação de ano de publicação e idioma. **Critérios de seleção**: estudos que respondessem a pergunta norteadora: qual o uso da fotobiomodulação na musculatura de cabeça e pescoço?. **Resultados**: Foram encontrados 2857 artigos, sendo selecionados 102 para leitura completa, dos quais 52 foram excluídos, totalizando 50 artigos incluídos. As publicações incluídas datam de 2003 a 2020. O Brasil foi o país que mais publicou sobre o tema. Quanto aos objetivos, 82% dos estudos pesquisaram o efeito analgésico da fotobiomodulação, e desses, 50% eram relacionados à disfunção temporomandibular (DTM) articular ou muscular. A heterogeneidade dos estudos impossibilita a definição de protocolos dosimétricos. **Conclusão**: A fotobiomodulação tem sido utilizada na musculatura de cabeça e pescoço principalmente para o tratamento da dor proveniente de DTM. Não existe um protocolo de aplicação que defina os parâmetros dosimétricos a serem utilizados, devido a heterogeneidade das metodologias e dos resultados encontrados.

Palavras-chave: Laserterapia; Músculo masseter; Músculos faciais; Músculo do pescoço; Síndrome da disfunção da articulação temporomandibular

Study conducted at Universidade Federal de Pernambuco – UFPE – Recife (PE), Brasil.
[1]Universidade Federal de Pernambuco, Recife (PE), Brasil.
[2]Hospital Pronto Socorro Municipal Mário Pinotto, Belém(PA), Brasil.
Conflict of interests: No.
Authors' contribution: SLSF, DAC, RSAB, HJS made substantial contributions to the conception and design, data analysis and interpretation, and critical review of the manuscript; SLSF, ALSA, MDC performed the data acquisition and draft of the manuscript.
Funding: Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – (CAPES) Brasil– Finance code 001; Fundação de Amparo à Ciência e Tecnologia do Estado de Pernambuco (FACEPE) – Brasil.
Corresponding author: Sara Loureiro de Souza Ferreira. E-mail: saraferreirafono@gmail.com
Received: July 26, 2021; **Accepted:** November 12, 2021

INTRODUCTION

Photobiomodulation (PBM) or phototherapy refers to the use of low intensity light, as Light Emitting Diode (LED) or Light Amplification by Stimulated Emission of Radiation (LASER), with different goals depending on the person's biological needs. Thanks to its biomodulating action on cellular functions, this treatment may promote analgesic effect, modulation of inflammation and edema, tissue repair and, more recently, studies already show its effect on muscle performance [1–3].

The studies have confirmed that the use of laser and LED of red and infrared wavelengths increases the fatigue resistance of muscles and decreases the recovery time after intense physical activities, both in normal individuals and athletes, when the treatment is applied to larger muscle groups, such as quadriceps and biceps [3-4]. This results from the effect of light on cellular respiration, providing more energy for the tissue, improving muscle performance, including the head and neck muscles [5].

Regarding this latter muscle group, the published research so far focuses on the use of PBM in individuals with temporomandibular disorders (TMD), bruxism, trigger points, and myofascial pain [6–8]. Though the use of laser and LED are increasing, it is important to systematize the knowledge about the ways the low-level light therapy (LLLT) is used for the muscles of the head and neck and to define the protocols of irradiation.

OBJECTIVE

This study aimed to carry out an integrative review of the literature on the use of PBM for the head and neck muscles.

RESEARCH ESTRATEGIES

An integrative review was carried out to identify studies that answered the guiding question: what is the use of photobiomodulation applied to the head and neck muscles?, in the following databases: PubMed, Scopus, Web of Science, LILACS, and SciELO. The research was done by two independent researchers between June/2019 and March/2021, and then the results were compared to each other. If the findings of the research diverged in means of inclusion, two judges were asked to analyze the studies and to reach a consensus. The MeSH terms used in the research were Low-Level Light Therapy, Phototherapy, Masseter Muscle, Masticatory Muscles, Tongue, Palate, Mouth, Neck Muscles and Facial Muscles. Their Portuguese equivalents were also used, as well as free terms in Portuguese: photobiomodulation, lasertherapy, craniofacial muscles, oral cavity, extrinsic muscles of the larynx and intrinsic muscles of the larynx.

The terms were crossed in pairs as follows: Low-Level Light Therapy AND Masseter Muscle; Low-Level Light Therapy AND Masticatory Muscles; Low-Level Light Therapy AND Tongue; Low-Level Light Therapy AND Palate; Low-Level Light Therapy AND Mouth; Low-Level Light Therapy AND Neck Muscles; Low-Level Light Therapy AND Facial Muscles; Phototherapy AND Masseter Muscle; Phototherapy AND Masticatory Muscles; Phototherapy AND Tongue; Phototherapy AND Palate; Phototherapy AND Mouth; Phototherapy AND Neck Muscles; Phototherapy AND Facial Muscles. The free terms were crossed as follow: Photobiomodulation AND Craniofacial Muscles; Photobiomodulation AND Oral Cavity; Photobiomodulation AND Extrinsic Muscles of the Larynx; Photobiomodulation AND Intrinsic Muscles of the Larynx; Lasertherapy AND Craniofacial Muscles; Lasertherapy AND Oral Cavity; Lasertherapy AND Extrinsic Muscles of the Larynx; Lasertherapy AND Intrinsic Muscles of the Larynx.

SELECTION CRITERIA

The review included original articles that answered the research question, with no distinction of language or time limitation. The exclusion criteria were: animal research, articles in which the phototherapy was used for static structures of the head and neck, literature reviews, case studies, theses, dissertations, and books.

DATA ANALYSIS

From the selected articles, the following variables were chosen for analysis: Author, year of publication and country where the research was conducted; main objective of the study; number of participants, their respective health conditions and allocation into groups; the evaluations carried out to achieve the objectives; photobiomodulation parameters referring to the specifications of the device used and its settings, such as wavelength, power, fluence; the treatment protocol: areas of irradiation, number of points, frequency of application, irradiation time and total number of sessions; and main results obtained. For methodological analysis of the included articles, the PEDro scale[9] was used.

RESULTS

It was found 2857 articles in the databases, 2182 of which were excluded after reading the title and abstract. Of the remaining 675 articles, 573 were repeated, and 102 were selected for complete reading, of which 52 were excluded during this stage, giving a total of 50 articles included in the study. At all stages, the exclusion criteria were animal studies, literature reviews, case studies, use of high-intensity laser for surgery, and application in static structures, such as jaw and teeth. To achieve the proposed objectives, the obtained results were systemized in a table (Table 1).

The first work with the use of PBM applied to the head and neck muscles was published in 2003, and from 2003 to 2009, nine articles were published on the topic; in the last ten years (from 2010 to 2021), this number increased to 41, the last article included in the study is from 2020.

Brazil is the country that most published on the subject, with 28 articles (56%), most of which were published in international journals. Iran comes after Brazil with seven publications (14%) and Turkey with six publications (12%), Bulgaria with two (4%), and the other countries with one article each.

With regard to the objectives, 82% of the studies (n = 41) aimed to research the analgesic effect of phototherapy, and of these, 50% (n = 25) were related to articular or muscular TMD. Out of 50, five studies (10%) compared the LED and

Table 1. Summary of the studies included for analysis

Author/year/ country	Objectives	Participants/clinical condition/groups	Evaluations	Photobiomodulation parameters	Protocol	Results
Tullberg et al., 2003, Switzerland [10]	To investigate the immediate effects of laser therapy on the blood circulation of the masseter muscle	12 Patients with chronic orofacial pain and 12 healthy individuals, randomized into experimental and placebo group. Mean age 43 years.	Pain in palpated muscle, maximum opening of the mouth, intramuscular blood circulation	LASER IV, 74mW, 2 min application, 8.9J	Application on the most painful point of the masseter muscle, unilateral in the symptomatic individuals. In the asymptomatic ones, application on the most prominent point of the right masseter. Both applications lasted two minutes.	The pain intensity did not change significantly after the laser. In the group of patients, there was no change in blood circulation. In the healthy group, there was an increase in blood circulation after the laser had been applied and a decrease after the placebo. Low microcirculation was associated with greater pain intensity.
Ilbuldu et al., 2004, Turkey [11]	To evaluate the effectiveness of laser therapy in the treatment of myofascial pain syndrome	60 patients with trigger points in the upper trapezius muscles, Group 1 stretching + placebo, Group 2 stretching + acupuncture, Group 3 stretching + laser. Mean age 33 years.	VAS for pain, amplitude of cervical movement, and functional status	Laser V (632.8nm), 2J/pt	Irradiation on three trigger points on the upper trapezius muscles on both sides, three times a week for 12 sessions	Significantly eased pain at rest and in activity and increase in pain threshold in group 3.
Medeiros et al., 2005, Brazil [12]	To evaluate the effects of laser on the bite strength of the masseter muscle in patients with orofacial pain	15 patients with pain in the masseter muscle, all of them were treated with laser and placebo. Mean age not specified.	Bite strength	Laser V, 670 nm, 15 mW, 2J/cm^2, 14.3min	Irradiation throughout the whole masseter muscle, obliquely to the fibers, 2 mm away, scanner	All the patients improved the muscle contraction strength from approximately 2.51 to 3.01 kgF
Çetiner et al., 2006, Turkey [13]	To evaluate the efficacy of laser therapy in the treatment of myogenic TMD	39 patients with myogenic orofacial pain associated with TMD, divided into laser group (n = 24) and placebo group (n = 15). Mean age 33 years.	Degrees of pain with VAS, maximum opening of the mouth, and lateral movements of the mandible	Laser IV (830 nm), 162s; dose 7J/cm^2, localized contact	Irradiation on the four most sensitive points (joint capsule, masseter, temporal, medial and lateral pterygoids), 10 daily sessions for 2 weeks	Improvement in maximum mouth opening, eased pain, and lessened chewing difficulty
Sebbe et al., 2006, Brazil [14]	To analyze the application of laser to prevent induced muscle fatigue in the masseter muscle	10 subjects without complaints, laser V group and laser IV group. Age range from 21 to 29.	Electromyographic signs of muscle activity, time of fatigue, maximum and mean strength	Laser V (685 nm) and IV (830nm), 30 mW, 4J/cm^2, 5s/point	Irradiation in 8 points of the masseter, with a distance of 1 cm between the points. Single application	The laser therapy employed in this study was not effective to prevent muscle fatigue

Subtitle: mW = miliwatts; IV = infrared; V = red; nm = nanômeter; VAS = visual analogic scale; J = joules; pt = point; J/pt = joules per point; J/cm^2 = joules per square centimeter; TMD = temporomandibular disorder; TMJ = temporomandibular joint; s = seconds; min = minutes; TENS = transcutaneous electrical stimulation; IMES = intramuscular electrical stimulation; W = watt; Hz = Hertz; mm = milimeter; Kgf = kilogram-force; EMG = surface electromyography; OMES = orofacial myofunctional evaluation with scores; CP = cerebral palsy; RDC/TMD = Research diagnostic criteria for temporomandibular disorders; SF-MPQ = Short-form McGill Pain Questionnaire; NDI = Neck disability Inde

Table 1. C0ntinued...

Author/year/ country	Objectives	Participants/clinical condition/groups	Evaluations	Photobiomodulation parameters	Protocol	Results
Shinokazi et al., 2006, Brazil [15]	To evaluate the immediate efficiency of laser therapy in patients with TMJ disorder and pain	13 patients with myofascial pain and TMJ disorder, application on the side with greater symptomatology and contralateral side as the control. Age range from 18 to 36 years.	Subjective assessment of pain and electromyography of the masseter and temporal muscles	Laser IV (790 nm), 40mW, 3J/cm^2	Irradiation in three points on the masseter, and three points on the temporal	Reduced electrical activity after the application of laser, immediate relaxation of the muscles, and eased pain
Núñez et al., 2006, Brazil [16]	To evaluate the effectiveness of laser therapy and electrical stimulation (TENS) in the mouth opening of patients with TMD	10 patients with multiple-cause TMD, the participants alternately received both treatments. Mean age 34 years.	Amplitude of mouth opening	Laser V (670nm), 50 mW, 60s/pt, 3J/pt	Irradiation in 4 places: masseter muscle, temporal muscle, mandibular condyle, and intra-auricular. Single session	Significant improvement in the amplitude of mouth opening in both therapies; the laser therapy was significantly greater than TENS
Kato et al., 2006, Brazil [17]	To compare TENS with laser therapy in the treatment of patients with TMD	18 patients with chronic TMD of muscular origin, divided into laser group and TENS group. Mean age 25 years.	VAS for pain, maximum mouth opening, and palpation of the masseter and anterior temporal muscles	Laser IV (830 to 904nm), 100mW, 4J/cm^2, 9 min each side of the face	Irradiation in face sweeping (muscles not specified), 10 sessions, 3 times a week, for 4 weeks	A decrease in VAS, increase in maximum mouth opening of both groups and muscle palpation with a significant difference for the laser group
Shirani et al., 2009, Iran [18]	To evaluate the efficacy of laser to ease the pain in the masticatory muscles	16 patients with myofascial dysfunction. Experimental and placebo group. Mean age 23 years.	VAS for pain	Laser V (660nm), continuous, 6.2J/cm^2, 6 min; and IV (890 nm), pulsatile, peak 9.8W, 1J/cm^2, 1500 Hz for 10 min	Irradiation on the painful masticatory muscles, twice a week for 3 weeks	The pain eased significantly before and after the treatment in both groups; however, laser therapy was more effective
Öz et al., 2010, Turkey [19]	To compare the effects of laser with an occlusal splint in patients with myofascial pain syndrome	40 patients with TMD and myofascial pain in the masticatory muscles, divided into laser group and occlusal splint group. Mean age 32 years.	Pain thresholds with pressure, with algometer and VAS for pain	Laser IV (820 nm), 3J/cm^2, power 300 mW, 10 sec.	Irradiation on the trigger points, 2mm away, twice a week, 10 sessions	Sensitivity to palpation and pain threshold with pressure decreased and the pain eased in both groups. The laser was as effective as the occlusal splints in the treatment of myofascial pain.
Shinozaki et al., 2010, Brazil [20]	To evaluate the immediate efficacy of laser therapy in women with TMD and pain	13 women with facial pain in the masseter and temporal muscles. Age range from 18 to 36 years.	EMG of the masseter and anterior temporal muscles	Laser IV (790nm), 1.5J/cm^2 on the TMJ, and 3J/m^2 on the masseter muscle	Irradiation in 6 TMJ points and 3 points on the masseter muscle	Reduced electromyographical activities after the laser therapy and significant immediate relaxation of the masseter muscles

Subtitle: mW = miliwatts; IV = infrared; V = red; nm = nanômeter; VAS = visual analogic scale; J = joules; pt = point; J/pt = joules per point; J/cm^2 = joules per square centimeter; TMD = temporomandibular disorder; TMJ = temporomandibular joint; s = seconds; min = minutes; TENS = transcutaneous electrical stimulation; IMES = intramuscular electrical stimulation; W = watt; Hz = Hertz; mm = milimeter; Kgf = kilogram-force; EMG = surface electromyography; OMES = orofacial myofunctional evaluation with scores; CP = cerebral palsy; RDC/TMD = Research diagnostic criteria for temporomandibular disorders; SF-MPQ = Short-form McGill Pain Questionnaire; NDI = Neck disability Inde

Table 1. C0ntinued...

Author/year/ country	Objectives	Participants/clinical condition/groups	Evaluations	Photobiomodulation parameters	Protocol	Results
Balestra et al., 2011, Brazil [21]	To compare the effect of laser and LED on the temperature of the region of the face	9 healthy individuals, with no systemic or head and neck pathologies. Mean age 28 years.	Thermogram every 5 minutes, for 30 minutes	Laser: V, 30mW power, localized, 7.5J/cm², 10 s, 0.3J energy. LED: V, 30mW power, 4J/cm², localized, 20 seconds, 0.6J energy	Irradiation on the masseter with laser or LED on the left side of the face, 8 points	The laser group did not present intragroup differences. For the LED, there was an intragroup difference at 5 minutes, with a decrease in temperature. In the comparison between groups, there was a significant difference at five minutes with a decrease in temperature with LED.
Kelencz et al., 2010, Brazil [22]	To analyze the effect of LED on the electrical activity, strength, and fatigue of the masseter muscle	30 healthy individuals divided into 3 groups (G1: 1044J/pt; G2: 2088 J/pt; G3: 3132 J/pt). Mean age 23 years.	Bite strength and electrical activity	LED V (640nm), 116mW, G1 1044J/pt; G2 2088 J/pt; G3 3132 J/pt, fluency of 2, 4 or 6J/cm²	Single irradiation on eight points of the masseter	Increase in the electrical activity of the masseter for G1. The resistance to fatigue increased significantly for G2. There was no difference in bite strength.
Silva et al., 2012, Brazil [23]	To evaluate the effect of laser on TMD	45 individuals with signs and symptoms of chronic TMD, divided into 3 groups (G1: 52.5J/cm²; G2: 105.0J/cm², G3: placebo). Age range from 25 to 53 years.	Maximum mouth opening, jaw laterality, and protrusion; VAS for pain with palpation	Laser IV (780nm), 70mW, continuous	Irradiation on the TMJ (5 points), three points on the masseter, and one on the temporal, two sessions a week for 5 weeks	Increase in mandibular mobility and decrease in painful symptoms; G2 had a quicker response.
Gokçen-Rohlig et al., 2013, Turkey [24]	To evaluate the effect of laser on bite strength, area of occlusal contact, and occlusal pressure	20 individuals with TMD and 20 healthy ones for the control group. Mean age 33 years.	Pain threshold with pressure, mandibular movements, bite strength, occlusal contact area, and occlusal pressure	Laser IV (820nm), 3J/cm², 300mW, 10 s.	Irradiation on the trigger points, 2mm away, 3 times a week, totaling 10 sessions	Increase in values of pain threshold with pressure and mandibular mobility, decrease in pain with palpation, with no effect for bite strength, area of occlusal contact and occlusal pressure
Melchior et al., 2013, Brazil [1]	To verify whether laser eases the pain and whether this brings about changes in the oromyofacial functions	12 women diagnosed with myofascial pain. Age range from 18 to 60 years.	VAS for pain with palpation and OMES	Laser IV (780nm), 60mW, 40 seconds, 60J/cm², 2.8J/pt	Irradiation on the most sensitive points of the upper, medial, and lower masseter, and one point on the anterior temporal. Two sessions a week, for 4 weeks	Significant decrease in pain with palpation, with no differences in OMES

Subtitle: mW = miliwatts; IV = infrared; V = red; nm = nanômeter; VAS = visual analogic scale; J = joules; pt = point; J/pt = joules per point; J/cm² = joules per square centimeter; TMD = temporomandibular disorder; TMJ = temporomandibular joint; s = seconds; min = minutes; TENS = transcutaneous electrical stimulation; IMES = intramuscular electrical stimulation; W = watt; Hz = Hertz; mm = milimeter; Kgf = kilogram-force; EMG = surface electromyography; OMES = orofacial myofunctional evaluation with scores; CP = cerebral palsy; RDC/TMD = Research diagnostic criteria for temporomandibular disorders; SF-MPQ = Short-form McGill Pain Questionnaire; NDI = Neck disability Inde

Table 1. C0ntinued...

Author/year/ country	Objectives	Participants/clinical condition/groups	Evaluations	Photobiomodulation parameters	Protocol	Results
Carli et al. 2013, Brazil (25)	To evaluate the effectiveness of piroxicam in combination with laser therapy in the treatment of TMJ pain	32 individuals with pain in at least one TMJ, divided into 3 groups (G1 laser and piroxicam placebo; G2 laser placebo and piroxicam; G3 laser and piroxicam). Mean age 38 years.	VAS for pain at rest, pain intensity with palpation, maximum mouth opening	Laser IV (808nm), 100mW, 28 s per point, 100J/cm² per point, 2.8J/pt	Irradiation on 10 points: 5 on TMJ, 2 on masseter, and 3 on temporal, twice a week for 10 days	All the groups eased the pain, with no differences between them. The values of mouth opening did not present any difference. The three groups improved in masseter palpation.
Uemoto et al., 2013, Brazil (26)	To compare laser with acupuncture in patients with myofascial pain	21 women with TMD and myofascial trigger points in the masseter, divided into 3 groups (laser group, needle group, control group). Age range from 20 to 52 years.	VAS for spontaneous pain, pain threshold with pressure, maximum mouth opening, electrical activity	Laser IV (795nm), 80mW, 4J/cm² per point on the right masseter muscle and 8J/cm² on the left masseter muscle	Irradiation on the myofascial trigger point present in the masseter, 4 sessions with an interval of 72 to 48 hours.	Significant improvement in both groups regarding pain, significant improvement in pain threshold with palpation in the laser group 4J/cm², with no changes in electrical activity and maximum mouth opening
Ahrari et al., 2014, Iran (27)	To investigate the efficacy of laser therapy in the improvement of signs and symptoms of patients with myogenic TMD	20 female patients with myogenic TMD, divided into experimental and placebo groups. Mean age 35 years.	VAS for pain with palpation and maximum mouth opening	Laser IV, pulsed, localized contact, energy of 6J/pt, fluency 3.4 J/cm²	Three times a week for 4 weeks on the painful points of the masseter, temporal, and medial pterygoid muscles	Increased maximum mouth opening and eased the pain in the experimental group; however, when the groups are compared, there was no significant difference in maximum mouth opening and VAS
Maia et al., 2014, Brazil (28)	To evaluate the effect of laser therapy in the masticatory performance, pain threshold with pressure, and pain intensity in patients with masticatory myofascial pain	21 individuals with myofascial pain, divided into laser group and placebo group. Mean age 27 years.	Masticatory performance, pain threshold with pressure, and AVS for pain intensity	Laser IV (808nm), 100mW, 1.9J total energy, 70J/cm², 19s per point	Irradiation on the trigger points of the temporal and masseter, 5 points on each muscle, no contact, twice a week for 1 month, totaling 8 sessions	Improvement in masticatory performance and an increase in pain threshold with pressure in the laser group. Regarding pain, both groups had improvements.
Madani et al., 2014, Iran (29)	To investigate the efficacy of laser therapy in the treatment of TMJ osteoarthritis	20 individuals with TMJ osteoarthritis. Age range from 35 to 60 years.	VAS for pain intensity and maximum mouth opening	Laser IV (810nm), pulsed, mean power 50mW, 6J/pt, 3.4J/cm², 2 min per point	Irradiation on four points of the TMJ and the painful muscles (masseter, temporal, and medial pterygoid), 3 times a week for 4 weeks	Increase in maximum mouth opening, though with no statistical difference. For VAS, significant intragroup improvement, with no difference between the groups.

Subtitle: mW = miliwatts; IV = infrared; V = red; nm = nanômeter; VAS = visual analogic scale; J = joules; pt = point; J/pt = joules per point; J/cm² = joules per square centimeter; TMD = temporomandibular disorder; TMJ = temporomandibular joint; s = seconds; min = minutes; TENS = transcutaneous electrical stimulation; IMES = intramuscular electrical stimulation; W = watt; Hz = Hertz; mm = milimeter; Kgf = kilogram-force; EMG = surface electromyography; OMES = orofacial myofunctional evaluation with scores; CP = cerebral palsy; RDC/TMD = Research diagnostic criteria for temporomandibular disorders; SF-MPQ = Short-form McGill Pain Questionnaire; NDI = Neck disability Inde

Table 1. C0ntinued...

Author/year/ country	Objectives	Participants/clinical condition/groups	Evaluations	Photobiomodulation parameters	Protocol	Results
Nencheva-Svechtarova et al., 2014, Bulgaria [30]	To evaluate the effectiveness of laser and superluminous LED in pain intensity in people with TMD and chronic myofascial disorders	45 individuals with chronic symptoms of myofascial and/or joint pain. Single group. Age range from 17 to 70 years.	VAS for pain intensity	Laser IV (785nm), 8J/cm², 100s. Superluminous LED V (633nm), 200mW, 300s, 8J/cm²	Irradiation on trigger points, 3 times a week for 2 weeks. Laser on the TMJ, temporal, pterygoids, and sternocleidomastoids, and laser + LED on the masseter and trapezius	Significantly eased the pain in the TMJ and masseter, with no difference for the other muscles
Godoy et al., 2015, Brazil [31]	To evaluate the effect of laser therapy on pain, mandibular movements, and occlusal contact in adolescents and young adults with TMD	9 adolescents and young adults with TMD, divided into 2 groups: laser and placebo. Age range from 14 to 23 years.	Maximum occlusal contact, maximum mouth opening, VAS for pain with palpation	Laser IV (780 nm), 33.5 J/cm², 50mW, 20s, 1J/pt	Irradiation on three points of the masseter and one point on the temporal, two sessions a week, for 6 weeks	No statistically significant differences before and after the treatment and between the groups
Panhoca et al., 2015, Brazil [32]	To evaluate the effects of LED V and IV on the temperature of the ex vivo tissue, and pain relief and mandibular movements of patients with TMD	30 individuals with TMD divided into 3 groups (G1: red LED; G2: infrared LED; G3 laser). Age range from 18 to 50 years.	Maximum mouth opening, scale for pain with palpation	LED V (630nm) and LED IV (850nm) both with power of 150mW, 9J per point and fluency of 18J/cm². Laser IV (780nm), 70mW, 4.2J/pt and fluency of 105J/cm²	Irradiation on five points, three on TMJ, one on the temporal, and one on the masseter. Two sessions a week for 4 weeks.	Significantly eased the pain in all groups, a significant increase in maximum mouth opening in all groups
Sumen et al., 2015, Turkey [33]	To evaluate the efficacy of IMES and laser therapy in patients with myofascial pain	45 individuals with myofascial pain and active trigger points, divided into 3 groups (G1: laser + stretching; G2: IMES + stretching; G3: stretching). Mean age 41 years.	VAS for pain intensity, pain threshold with pressure, cervical movement	Laser V (670nm), 4J/cm², pulsatile, maximum power of 5mW	Irradiation on the upper trapezius five times a week for two weeks, for 10 minutes	Improvement in all parameters in both groups
Cavalcanti et al., 2016, Brazil [34]	To evaluate the effectiveness of laser in the treatment of pain associated with TMD	60 women with moderate and severe TMD randomized into laser group, placebo group, and conventional therapy group. Age range from 20 to 50 years.	Pain with muscle palpation	Laser IV (780nm), 70mW, 1.4J/point, 20s, fluency 35J/cm²	Irradiation in five points: lateral pterygoid (intraoral), intra-auricular, preauricular, insertion and origin of the masseter; for 20 seconds, every other day, for 4 weeks	In the last reassessment, all the patients of the placebo group presented pain, whereas none of the patients in the laser and conventional therapy group presented pain.

Subtitle: mW = miliwatts; IV = infrared; V = red; nm = nanômeter; VAS = visual analogic scale; J = joules; pt = point; J/pt = joules per point; J/cm² = joules per square centimeter; TMD = temporomandibular disorder; TMJ = temporomandibular joint; s = seconds; min = minutes; TENS = transcutaneous electrical stimulation; IMES = intramuscular electrical stimulation; W = watt; Hz = Hertz; mm = milimeter; Kgf = kilogram-force; EMG = surface electromyography; OMES = orofacial myofunctional evaluation with scores; CP = cerebral palsy; RDC/TMD = Research diagnostic criteria for temporomandibular disorders; SF-MPQ = Short-form McGill Pain Questionnaire; NDI = Neck disability Inde

Table 1. C0ntinued...

Author/year/ country	Objectives	Participants/clinical condition/groups	Evaluations	Photobiomodulation parameters	Protocol	Results
Carli et al., 2016, Brazil (35)	To compare the effectiveness of laser with that of botulinum toxin A for myofascial pain	15 individuals with myofascial pain and difficulty to open the mouth, randomized into laser group and toxin group. Mean age 38 years.	Maximum mouth opening and VAS for pain	Laser IV (830nm), 100mW, continuous emission, fluency 80J/cm²	Irradiation on localized contact on two points of the masseter (origin and insertion) and one on the temporal, bilaterally. Seven applications with intervals of 48 hours.	The laser group significantly eased the pain 12 days after beginning the irradiation. The toxin group, only after 30 days from the first application. None of the groups had a significant improvement in mouth opening during the treatment.
Magalhães et al., 2016, Brazil (36)	To investigate the effects of laser therapy in blood circulation speed, cholinesterase, and serotonin levels	10 women with a chronic headache associated with TMD. Age range from 20 to 50 years.	Mandibular mobility, pain with movement, pain with muscle palpation; Doppler ultrasound for blood circulation velocity; blood analysis	Laser IV (830nm), 100mW, 3.4J, 110J/cm²	Single irradiation on the painful points of the masseter and temporal, for 34s	Pain intensity decreased significantly; the blood circulation velocity decreased significantly; the serotonin levels increased.
Santos et al., 2016, Brazil (37)	To evaluate the effect of laser therapy on the spasticity of the masseter and temporal anterior muscles	30 children with spastic CP. Mean age 10 years.	Bite strength and maximum mouth opening	Laser IV (808nm), fluency of 3J/cm², 2.4J/pt	The masseter and temporal muscles were irradiated for 20s on one point, for three consecutive weeks, totaling 6 applications	Decreased bite strength and increased maximum mouth opening were found after 3 weeks of application
Alayat et al., 2017, Egypt (38)	To evaluate the efficacy of the multiwave locked system (MLS) and laser IV in the treatment of patients with chronic cervical pain	75 men with chronic cervical pain. Mean age 46 years.	Cervical dysfunction index, VAS for cervical pain	Laser IV, a mean energy density of 50J/cm², scanner mode	Scanner phase: applied on the neck extensors, sternocleidomastoid, and upper, medial, and lower trapezius. Trigger points phase: eight trigger points, 4 on each side of the posterior region of the neck	Decreased values of VAS and cervical dysfunction index after the treatment, compared with the base values
Costa et al., 2017, Brazil (39)	To determine the effects of laser therapy on the analgesia of the masticatory muscles	60 individuals with pain in the masseter and temporal muscles. Mean age 38 years.	VAS and algometer for pain and muscle palpation, maximum mouth opening	Laser IV (830nm), 100mW, fluency of 100J/cm², 28s per point, 2.8J/pt	Five irradiation points: anterior, medial, and posterior temporal, and upper and lower masseter. Single application.	Significantly eased the pain with algometer in both groups, with the VAS, no difference. No significant difference in maximum mouth opening.

Subtitle: mW = miliwatts; IV = infrared; V = red; nm = nanômeter; VAS = visual analogic scale; J = joules; pt = point; J/pt = joules per point; J/cm² = joules per square centimeter; TMD = temporomandibular disorder; TMJ = temporomandibular joint; s = seconds; min = minutes; TENS = transcutaneous electrical stimulation; IMES = intramuscular electrical stimulation; W = watt; Hz = Hertz; mm = milimeter; Kgf = kilogram-force; EMG = surface electromyography; OMES = orofacial myofunctional evaluation with scores; CP = cerebral palsy; RDC/TMD = Research diagnostic criteria for temporomandibular disorders; SF-MPQ = Short-form McGill Pain Questionnaire; NDI = Neck disability Inde

Table 1. C0ntinued...

Author/year/ country	Objectives	Participants/clinical condition/groups	Evaluations	Photobiomodulation parameters	Protocol	Results
Hosgor et al., 2017, Turkey [40]	To evaluate the effectiveness of four treatments for TMD: pharmacological, intraoral stent, laser therapy, and arthrocentesis	40 individuals with unilateral TMD. The side of the asymptomatic TMJ was considered the control group. Mean age 30 years.	maximum mouth opening and VAS for pain, joint clicking, MRI of the TMJ	Laser IV (1064nm), 500mW per 180s, 321J/cm^2	Irradiation on the temporal and masseter muscles and the mandibular condyle, 1 to 2 cm away from the skin, 3-minute sessions, three times a week, for 4 weeks	Mouth opening increased and the pain eased in all the groups, with no statistical difference between them
Kagan et al., 2017, USA [41]	To determine the effectiveness of LED therapy in easing the symptoms of vocal fatigue	16 adults with no vocal complaints, LED group, placebo group, and heat group. Age range from 22 to 35 years.	Acoustic and aerodynamic evaluation and self-evaluation of vocal effort	Simultaneous LED V (628) and IV (828) matrix, for 20 min	The LED matrix was placed on the region over the thyroid cartilage lamina, bilaterally, for 20 minutes	All the groups worsened after the vocal fatigue exercise and improved after the treatment, in the immediate assessment, and after 1h. Only in the red LED group, the improvement was significant after 1h.
Magri et al., 2017, Brazil [6]	To analyze the effect of laser therapy on pain intensity, orofacial and body sensitivity in specific points, and on the SF-MPQ	108 women, 66 with myofascial pain, divided into laser group, placebo group, and control group. Mean age 38 years.	VAS for pain, pain threshold with palpation, SF-MPQ	Laser IV (780nm), 5J/cm^2, power 20mW, 10s/pt	Irradiation on three points of the masseter and temporal muscles and TMJ; two sessions a week for 4 weeks	Significantly eased the pain for laser and placebo, with no changes in pain threshold with pressure between the laser and placebo groups and with no significant changes in the questionnaire
Rezazadeh et al., 2017, Iran [42]	To evaluate the effectiveness of TENS and laser therapy in the treatment for TMD without drug response	45 individuals with drug-resistant TMD, divided into TENS group and laser group. Mean age 30 years.	VAS for pain evaluation, Helkimo protocol	Laser IV (980nm), fluency of 5J/cm^2, power 200mW	Irradiation on three regions bilaterally, including the joint and trigger points for 2.5min, eight sessions in two weeks	The pain in the TENS group decreased faster (2 sessions) than in the laser group (3 sessions) and remained significantly lower in the TENS group in all follow-up sessions
Santos et al., 2017, Brazil [43]	To evaluate the efficacy of laser in the width of the masseter and maximum opening of the mouth	52 children with spastic CP, an experimental group with complaints of oral hygiene, control group with no complaints of oral hygiene, control group without CP. Mean age 11 years.	Ultrasound of the masseter, maximum mouth opening	Laser IV (808nm), 120mW power, 3J/cm^2, 2.4J/pt, 20s	Irradiation on one point of the masseter, once a week for six weeks	The experimental group presented significantly higher values for the width of the masseter and maximum mouth opening after six applications

Subtitle: mW = miliwatts; IV = infrared; V = red; nm = nanômeter; VAS = visual analogic scale; J = joules; pt = point; J/pt = joules per point; J/cm^2 = joules per square centimeter; TMD = temporomandibular disorder; TMJ = temporomandibular joint; s = seconds; min = minutes; TENS = transcutaneous electrical stimulation; IMES = intramuscular electrical stimulation; W = watt; Hz = Hertz; mm = milimeter; Kgf = kilogram-force; EMG = surface electromyography; OMES = orofacial myofunctional evaluation with scores; CP = cerebral palsy; RDC/TMD = Research diagnostic criteria for temporomandibular disorders; SF-MPQ = Short-form McGill Pain Questionnaire; NDI = Neck disability Inde

Table 1. C0ntinued...

Author/year/ country	Objectives	Participants/clinical condition/groups	Evaluations	Photobiomodulation parameters	Protocol	Results
Brochado et al., 2018, Brazil [44]	To compare the effectiveness of photobiomodulation and manual therapy in the treatment of pain, restriction of movements, and psychosocial disorders and anxiety in TMD	41 individuals with myogenic or arthrogenic TMD, with pain and limited mouth opening. Laser group, manual therapy group, combined group. Mean age 44 years.	VAS for pain, RDC, Anxiety Questionnaire	Laser IV (808nm), localized contact, 100mW, 3.33W/cm^2, fluency of 133J/cm^2, 40 seconds per point, 4J/pt	Irradiation on 12 points: 5 On the TMJ region, 3 points on the masseter, 3 on the temporal, 1 on medial pterygoid. Three times a week for four consecutive weeks	All the groups significantly eased the pain, improved mouth opening, and calmed the anxiety
Godoy et al., 2018, Brazil [45]	To evaluate the effect of phototherapy in bite strength, mandibular mobility, sensitivity to palpation, and fatigue	52 healthy young individuals with no complaints, divided into laser group and placebo group. Age range from 18 to 23 years.	Bite strength, maximum mouth opening, and VAS for fatigue sensation	Laser IV (780nm), fluency of 25J/cm^2, 50mW, 20s/pt, 1J/pt	Irradiation on three points of the masseter, one on the temporal	There were no changes in mandibular mobility and bite strength; fatigue increased.
Herpich et al., 2018, Brazil [46]	To determine the immediate effects of phototherapy on pain intensity, pain threshold with pressure, mandibular movement, and electrical activity in women with TMD	60 women with TMD, divided into Group 1 (2.62J/pt),Group 2 (5.24J/pt), Group 3 (7.86J/pt), Group 4 (placebo). Age not specified.	VAS for pain intensity, pain threshold with pressure, maximum mouth opening, electrical activity of the masseter and temporal muscles	Super-pulsed laser-cluster IV (905nm), LED V (640nm), LED IV (875nm)	Irradiation on three points of the temporal and two on the masseter, Group 1 20 sec/pt; G2 40 sec/pt; G3 and 4 60 sec/pt	Significantly eased the pain immediately, 24h, and 48h in G1, 2, and 3. No differences in pain threshold with pressure, electrical activity, and mandibular mobility.
Lauriti et al., 2018, Brazil [47]	To evaluate the effect of photobiomodulation on bite strength, facial edema, mandibular movements, and pain in patients with mandibular fractures	12 men with mandibular fractures, divided into experimental and placebo group. Mean age 34 years.	Maximum mouth opening, jaw laterality, protrusion, edema measurement, and bite strength, VAS for pain	Laser V (659nm), continuous mode, 200 s, 21.6J/cm^2	Irradiation on 10 points (region of the incision, 3 on the masseter and 1 on the temporal, bilaterally) for 15 sessions, three sessions a week	The laser group presented a significant improvement in less time for laterality and protrusion, with no difference for maximum mouth opening. Also, significant improvement in bite strength when compared with the placebo. No difference for edema and pain
Mendonça et al., 2018, Brazil [48]	To evaluate the immediate effect of laser therapy on muscle fiber conduction velocity and electrical activity of the upper trapezius muscle	20 healthy individuals that received laser therapy and placebo. Mean age 23 years.	EMG	Laser IV (820nm), 30mW, 2J/pt totaling 18J, fluency of 72J/cm^2, 67s	Irradiation on nine points 1 cm away in three rows and three columns, on the medial region of the upper trapezius	No effect was found for muscle fiber conduction velocity; however, the laser significantly decreased the amplitude of the electromyographic signal

Subtitle: mW = miliwatts; IV = infrared; V = red; nm = nanômeter; VAS = visual analogic scale; J = joules; pt = point; J/pt = joules per point; J/cm^2 = joules per square centimeter; TMD = temporomandibular disorder; TMJ = temporomandibular joint; s = seconds; min = minutes; TENS = transcutaneous electrical stimulation; IMES = intramuscular electrical stimulation; W = watt; Hz = Hertz; mm = milimeter; Kgf = kilogram-force; EMG = surface electromyography; OMES = orofacial myofunctional evaluation with scores; CP = cerebral palsy; RDC/TMD = Research diagnostic criteria for temporomandibular disorders; SF-MPQ = Short-form McGill Pain Questionnaire; NDI = Neck disability Inde

Table 1. C0ntinued...

Author/year/ country	Objectives	Participants/clinical condition/groups	Evaluations	Photobiomodulation parameters	Protocol	Results
Rasca et al., 2018, Belgium [49]	To evaluate the effectiveness of laser therapy in mouth opening due to acute mandibular trauma	50 individuals with acute and painful posttraumatic trismus. Mean age 41 years.	Maximum mouth opening	Laser IV (810nm), 1W, scanner mode at a distance of 2 to 4 cm, 2cm per second	Irradiation on the regions of the TMJ, masseter and temporal, for 120 s, and internally on the medial pterygoid for 7s	Significant increase in maximum mouth opening
Souza et al., 2018, Brazil [50]	To compare the analgesic effect of lidocaine and laser therapy in painful points of patients with orofacial pain and fibromyalgia	66 individuals diagnosed with fibromyalgia and orofacial pain, divided into laser group and lidocaine group. Mean age 46 years.	VAS for pain intensity	Laser IV (780nm), 50mW, 2J, 50J/cm^2	Irradiation on the selected points for 40 s, 1cm away from the skin, two sessions a week for 6 weeks	Both groups presented significantly eased pain, with no statistical difference between them
Sveshtarov et al., 2018, Bulgaria [51]	To compare the pain relief with laser radiation dosage (785nm) and superluminous LED (633nm + 880nm) in the treatment of TMD	124 individuals with painful TMD. Mean age 40 years.	VAS for pain intensity	LED cluster V and IV, 500mW, 300s, 8J/cm^2 per point. Laser IV, 100 seconds, 8J/cm^2 per point. Mean of 33.51J per session, with 21.06J of laser and 12.25J of LED	The LED and laser clusters were positioned over the affected muscles and trigger points	The greatest decrease in pain was due to the LED dose, followed by laser + LED, and lastly, laser
Kiraly et al., 2018, Hungary [52]	To compare the effects of shockwave therapy and LLLT in patients suffering from myofascial pain syndrome of the trapezius	61 patients diagnosed with myofascial pain syndrome of the trapezius, divided into laser group and shockwave group. Mean age 62 years.	VAS for pain intesity, neck functionality and quality of life	Laser (not specified the wave length), scanner and pulsed mode; regions around the trigger point 2000Hz (800mW), 3J/cm^2 for 2 min; trigger point 5000Hz (2000mW), 9J/cm^2 for 2 min	Once daily for 15 days, over the trigger point and the region around it	Resting pain and pressure pain significantly decrease in both groups, neck functionality improved in both groups, the quality of life domains of physical function, energy and pain significantly improved in both groups
Mansourian et al, 2019, Iran [53]	To assess the efficacy of LLLT and TENS as adjunctive to pharmaceutical therapy for treatment of myofascial pain dysfunction syndrome	108 patients,divided into three groups: LLLT+drugtherapy; TENS+drug therapy; drug therapy. Mean age 29 years.	VAS for pain intensity	Laser IV (810nm), 0.2W,continuous wavelength, 2J/cm^2, 10s	10 sessions (2 per week), over painful muscles: masticatory muscles, sternocleidomastoid and trapezius	Pain intensity improved in LLLT and TENS groups in the third week of treatment with a significant difference from the drug therapy group
Chellappa et al, 2020, India [54]	To compare the effectiveness of TENS and LLLT for treatment of patients with TMD	60 patients with orofacial pain were randomly divided into two groups: LLLT and TENS. Age range from 18 to 25 years.	VAS for maximum pain-free mouth opening and pain intensity during palpation	Laser V (672nm), 50mW, 3J/point, scanning mode	2 sessions/week for 3 weeks. Irradiation on tender points of masseter, temporalis, condylar region and intra-auricular portion, for 120s	A significant decrease in VAS scores following LLLT and TENS were found, but LLLT group had a better outcome

Subtitle: mW = miliwatts; IV = infrared; V = red; nm = nanômeter; VAS = visual analogic scale; J = joules; pt = point; J/pt = joules per point; J/cm^2 = joules per square centimeter; TMD = temporomandibular disorder; TMJ = temporomandibular joint; s = seconds; min = minutes; TENS = transcutaneous electrical stimulation; IMES = intramuscular electrical stimulation; W = watt; Hz = Hertz; mm = milimeter; Kgf = kilogram-force; EMG = surface electromyography; OMES = orofacial myofunctional evaluation with scores; CP = cerebral palsy; RDC/TMD = Research diagnostic criteria for temporomandibular disorders; SF-MPQ = Short-form McGill Pain Questionnaire; NDI = Neck disability Inde

Table 1. C0ntinued...

Author/year/ country	Objectives	Participants/clinical condition/groups	Evaluations	Photobiomodulation parameters	Protocol	Results
Shahimoridi et al, 2020, Iran [55]	To examine the effectiveness of polarized low-level laser therapy in reduction of pain of myofascial trigger points in the trapezius muscle and compare with LLLT group	64 patients with MTP, randomly divided into two groups: PLLLT and LLLT with 32 subjects in each. Mean age 43 years.	VAS for pain intensity	Laser IV (755nm), 6J/cm^2, continuous mode, 160mW	Laser was applied to all painful trigger points of the trapezius, , 5 session a week per 2 weeks	The reduce in pain intensity was significant for both groups. The impact of LLLT on pain reduction was significantly greater than that of PLLLT.
Nadershah et al,2020, Saudi Arabia [56]	To examine the effectivesess of photobiomodulation in the treatment of myofascial type of TMD	202 patients diagnosed with unilateral myofascial pain TMD, randomly assigned into test group (n=108) and control group (n=94). Mean age 34 years.	VAS for pain intensity during function	Laser IV (940nm), 7w laser beam, 2.8 cm^2 spot size, continuous mode, 2 cm from the skin	Irradiation extraorally in 5 points: at the temporal, zygomatic, angle of the mandible, preauricular and mastoid areas, for 2 min, 24s/point, 120s total, 300J of energy total. Application occured every 48h for 10 days.	The test group VAS values were significantly different from the control group with the test group scoring lower pain
Mandani et al, 2020, Iran [57]	To compare the efficacy of LLLT vs laser acupuncture therapy (LAT) in TMD-affected patients. Mean age 32 years.	45 patients with TMD divided into 3 groups of 15 patients: Group 1 LLLT; Group 2 LAT; Group 3 placebo	VAS for pain intensity at rest and function, maximum pain-free mouth opening	Laser IV (810nm), 200mW, 30s/point, 21J/cm^2,continuous mode	Irradiation on tender muscle points, mandibular condyles and inside the external acoustic meatus, 10 sessions	The average pain scores reduced significantly in both LLLT and LAT groups but not on the placebo group

Subtitle: mW = miliwatts; IV = infrared; V = red; nm = nanômeter; VAS = visual analogic scale; J = joules; pt = point; J/pt = joules per point; J/cm^2 = joules per square centimeter; TMD = temporomandibular disorder; TMJ = temporomandibular joint; s = seconds; min = minutes; TENS = transcutaneous electrical stimulation; IMES = intramuscular electrical stimulation; W = watt; Hz = Hertz; mm = milimeter; Kgf = kilogram-force; EMG = surface electromyography; OMES = orofacial myofunctional evaluation with scores; CP = cerebral palsy; RDC/TMD = Research diagnostic criteria for temporomandibular disorders; SF-MPQ = Short-form McGill Pain Questionnaire; NDI = Neck disability Inde

laser, two (4%) used only LED, and the rest (86%, n = 43) used low-intensity laser for intervention.

The application protocols and the dosage parameters varied between studies, from the equipment and to the final dose used. As for the application sites, 38% of the studies (n= 19) irradiated the masseter and temporal muscles, including or not the temporomandibular joint (TMJ); in eight studies (16%), only the masseter muscle was irradiated. The masticatory muscles were also treated in ten studies (masseter, temporal, and pterygoid muscles). The next most common locations for irradiation were the trigger points in different locations (n= 6, 12%), and the superior trapezius muscle (n = 3). Two studies reported irradiation of the face without specifying the involved muscles, one study performed irradiation of the cervical muscles, and one of the larynx.

The most used wavelength was infrared, it was used in 68% (n = 34) of the studies. Red wavelength was used in eight studies, and the combination of the two was also used in eight studies (16% each). One study [45] did not specified the laser wavelength.

Overall, PBM showed positive results for the improvement of conditions related to pain (n= 34, 68%), increased mouth opening (n = 12), and decreased electrical activity of muscles (n = 4).

DISCUSSION

The use of red and infrared light, either by means of low intensity laser or LED, has been studied since the decade of 1960 when its PBM effects were accidentally discovered [58]. The work published by Tina Karu, in the decade of 1980, about the effects of light on biological tissues, increased the knowledge on the use potential of this technology for scientific purposes [59,60].

In 1989 it was suggested that the mechanism of PBM at the cellular level was based on the absorption of red and near infrared radiation by the components of the cellular respiratory chain. The topic has become increasingly relevant in recent years, and nowadays systematic reviews with meta-analysis on the use of LLLT in human muscles are available [3, 4, 61].

Nevertheless, the application of PBM to the head and neck muscle groups is still an area that has received little scientific attention, as there are only 50 studies available over the last 18 years. Yet, it is noticeable the significant increase in the number of studies published since 2010: 41 out of the 50 included studies. Brazil has emerged as a research hub in the topic of PBM applied to the head and neck muscles and has given the scientific community 56% of the published works.

We chose to group together the findings of the studies by the objective of the treatment; the objectives were analgesia, fatigue reduction, and, finally, blood circulation, electrical activity, mandibular mobility, temperature, biting force, and muscle thickness.

Pain

Most of the studies included in this integrative review presented positive results for pain management in the head and neck muscles [1,6,11,13,15,17-19,23-30,32-35,38-40,42,44,46,50-57]. For pain, there is evidence that PBM blocks the axonal transport of thin nerves, resulting in decreased mitochondrial membrane potential with a consequent decrease in the available ATP necessary for nerve function [11,62].

It is discussed that the analgesic mechanisms of PBM act by increasing the serotonin production and the synthesis of beta-endorphins, and improving the synaptic activity of acetylcholinesterase; in addition, it reduces the speed of action potentials and increase the latency of medial and sural nerves [11].

The doses used to achieve analgesia differed between studies, with 25 (50%) studies using the infrared wavelength, power between 20 and 500 mW, and fluence from 2 to 321J/cm^2.

The infrared wavelength with point contact and slight compression has a higher degree of penetration into the tissues, allowing irradiation of deeper muscle layers, which enhances the reach of the treatment. Besides, red and infrared wavelengths have a greater affinity with cellular mitochondria, the organelle responsible for cellular respiration. There is evidence that red and infrared light interacts with Cytochrome C-Oxidase, a chromophore present in the mitochondrial membrane, leading to increased oxygen consumption, the potential of the mitochondrial membrane, and ATP synthesis [63].

Regarding the pain related to masticatory performance, only one study[28] assessed it in individuals with myofascial pain. The results found an increase in the pressure pain threshold, improvement of pain, and consequent improvement in masticatory performance. The masticatory performance and the performance of other orofacial muscles, such as the orbicularis oris, responsible for lip sealing, and the suprahyoid muscles, directly related to the efficiency of swallowing, laryngeal elevation and anteriorization, should also be assessed in individuals without pain complaints. In addition, the investigation of the irradiation of the tongue would be interesting, as it is a muscle essential for stomatognathic functions such as speech, mastication and swallow.

One study [20] evaluated the electromyographic signal of the masseter and anterior temporal muscles in a group of women with pain in these muscles; the authors applied an infrared laser with fluence equal to 3J/cm^2 to three points of the masseter muscle and found a reduction in its electrical activity and a significant relaxation. Though pain was not directly assessed in this study, we can hypothesize that the muscle relaxation could have been caused by the analgesic effect of PBM.

Another study on the analgesic effect [12] evaluated the biting force of individuals with pain in the masseter muscle; after 14.3 minutes long irradiation with red laser in scanning mode with a fluence of 25J/cm^2. The authors found an increase in force from 2.51 to 3.01 KgF. It is believed that this effect also resulted from the decrease in pain, even though this variable has not been assessed.

Fatigue

Four articles addressed muscle fatigue and showed divergent results. Two studies [14,31] sought to evaluate the effect of laser on the prevention of induced fatigue of the masticatory muscles (masseter and temporal) in healthy individuals, however, neither of the two studies demonstrated a positive effect for fatigue prevention. It is important to take into account the doses used in both studies, as these may have been insufficient to trigger a cellular effect. In the first study [14], the researchers applied the laser to eight points of the masseter muscle for 5 seconds/

point with the fluence of 4 J/cm^2, whereas in the second [31] irradiated three points of the masseter muscle and one point of the temporal muscle, with 1 J/point and fluence of 25 J/cm^2.

Also assessing the induced fatigue in healthy individuals, a study [22] used PBM with red LED applied to eight points of the masseter muscle and found a positive effect on fatigue resistance for the group that was treated with 2.088 J/point. Randomized clinical studies with a larger number of participants and defined methodology are needed to allow the consolidation of the findings and their further generalization for clinical application.

There is a notable scarcity of studies on the application of PBM to the larynx muscles; currently, only one study has been published [41]. In clinical practice, therapy with laser has been used to improve vocal performance, especially in voice professionals, with a significant positive and immediate effect, but studies that systematize the use of this device and in fact prove its benefits for this application are still lacking.

This study [41] demonstrated a positive effect of the use of infrared LED light in case of an induced vocal fatigue and initiated the research in this area that is necessary for the elaboration of a protocol with defined doses and wavelengths, the application in phonotraumas, the preferred moment of intervention (pre-, post-, or both), and application in singers and other voice professionals.

Blood circulation, muscle electrical conductivity, mouth opening, temperature, biting force, and muscle thickness

Two studies sought to assess the effect of laser on blood circulation [10,36] associated also with analgesia. The infrared wavelength [10] was used at 8.9 J per point at the most painful point of the masseter muscle of individuals with chronic orofacial pain and found no significant changes in pain intensity and blood circulation. In another study [36], who used 3.4 J per point with the fluence of 110 J/cm^2 on the painful points of the masseter and temporal muscles, observed a significant reduction in pain and a reduction in the blood circulation speed. The authors explain the decrease in blood circulation speed by an increase of the temporal artery diameter.

With regard to the difference in the results found in the two studies, the number of irradiated points should be taken into account. In the second study [36], the exact number of irradiated points is not mentioned, but apparently all the painful points of the two muscles were treated, whereas in the first study [10] only one point in one muscle was irradiated, therefore, even with a higher applied energy value, it may have been insufficient for the desired effect.

One study [48] used the surface electromyography to evaluate the speed of conduction of the muscle fiber, applying an infrared laser at nine points of the upper trapezius muscle of healthy individuals at 2 J/point and fluence of 72 J/cm^2. The authors did not find differences in the analyzed variable, however, the laser treatment significantly reduced the amplitude of the EMG signal.

Two studies carried out with individuals with spastic cerebral palsy [37,43] found positive effects of IR laser irradiation applied to one point of the masseter muscle at the fluence of 3 J/cm^2, it resulted in the decreased biting force and increase mouth opening and masseter muscle thickness. These variables directly impact oral ingestion as well as the oral hygiene of these patients.

Two studies [16,49] evaluated mouth opening in patients with TMD [49] and acute trismus [16] and found an increase in this variable. Several other studies [13,17,23-27,29,32,39,40,46,51] that mainly focused on pain, also considered the mouth opening, and only five of them did not find a significant improvement in this parameter [25,26,39,45].

Finally, only one study [25] evaluated the effect of PBM on skin temperature of healthy subjects, finding a decrease in temperature for the LED group in comparison with the laser group, five minutes after irradiation; this temperature drop was not detectable after 30 minutes. The authors justify the temperature drop due to the vasodilation resulted from LED, which promoted a cooling of the tissue.

It is important to note that there are no published studies carried out by speech therapists. Speech therapists are professionals responsible for the assessment, diagnosis, and rehabilitation of orofacial myofunctional disorders, such as chewing, speech, and swallowing. Therefore, despite the fact that PBM is used in clinical practice, it requires robust scientific evidence to prove the benefits already observed in practice.

Although we did not use a MeSH term for muscular temporomandibular disorder on the research strategy, the majority of the studies found focused on the treatment of this disorder using the photobiomodulation. Perhaps if we had included a term related to it, more studies with this purpouse could have been found.

The heterogeneity of the studies turns it impossible to define the dose protocols. The first articles on the topic bring incomplete information about the parameters used, missing important parameters such as fluence, but the most recent articles are concerned with displaying all relevant information about the parameters and doses, as the next objective to be achieved is the definition of the optimal irradiation doses for each type of tissue and each wanted result. The fact that light has a biological interaction with tissues has already been proven, now it is necessary to understand the mechanisms at the cellular and molecular level and how does it change the tissue function.

CONCLUSION

Photobiomodulation has been applied to the head and neck muscles mainly for the treatment of pain caused by temporomandibular disorders. There is no application protocol that defines the doses to be used, due to the heterogeneity of the methodologies and results found. It is necessary to diversify the objects of research to consolidate knowledge in the area and finally define protocols for the clinical application of this tool.

ACKNOWLEDGEMENTS

Nothing to declare

REFERENCES

1. Melchior MO, Machado BCZ, Magri LV, Mazzetto MO. Effect of speech-language therapy after low-level laser therapy in patients with TMD: a descriptive study. CoDAS. 2016;28(6):818-22. http://dx.doi.org/10.1590/2317-1782/20162015099. PMid:28001273.

2. Gomes CF, Schapochnik A. O uso terapêutico do LASER de Baixa Intensidade (LBI) em algumas patologias e sua relação com a atuação na Fonoaudiologia. Distúrb Comun. 2017;29(3):570. http://dx.doi.org/10.23925/2176-2724.2017v29i3p570-578.

3. Nampo FK, Cavalheri V, Soares FS, Ramos SP, Camargo EA. Low-level phototherapy to improve exercise capacity and muscle performance: a systematic review and meta-analysis. Lasers Med Sci. 2016;31(9):1957-70. http://dx.doi.org/10.1007/s10103-016-1977-9. PMid:27272746.

4. Leal-Junior ECP, Vanin AA, Miranda EF, Carvalho PTC, Corso S, Bjordal JM. Effect of phototherapy (low-level laser therapy and light-emitting diode therapy) on exercise performance and markers of exercise recovery: a systematic review with meta-analysis. Lasers Med Sci. 2015;30(2):925-39. http://dx.doi.org/10.1007/s10103-013-1465-4. PMid:24249354.

5. Ferraresi C, Hamblin MR, Parizotto NA. Low-level laser (light) therapy (LLLT) on muscle tissue: Performance, fatigue and repair benefited by the power of light. Photonics Lasers Med. 2012;1(4):267-86. http://dx.doi.org/10.1515/plm-2012-0032. PMid:23626925.

6. Magri LV, Carvalho VA, Rodrigues FCC, Bataglion C, Leite-Panissi CRA. Effectiveness of low-level laser therapy on pain intensity, pressure pain threshold, and SF-MPQ indexes of women with myofascial pain. Lasers Med Sci. 2017;32(2):419-28. http://dx.doi.org/10.1007/s10103-016-2138-x. PMid:28054261.

7. Xu GZ, Jia J, Jin L, Li JH, Wang ZY, Cao DY. Low-level laser therapy for temporomandibular disorders: a systematic review with meta-analysis. Pain Res Manag. 2018;2018:4230583. http://dx.doi.org/10.1155/2018/4230583. PMid:29861802.

8. Salgueiro MCC, Bortoletto CC, Horliana ACR, Mota ACC, Motta LJ, Motta PB, et al. Evaluation of muscle activity, bite force and salivary cortisol in children with bruxism before and after low level laser applied to acupoints: study protocol for a randomised controlled trial. BMC Complement Altern Med. 2017;17(1):391. http://dx.doi.org/10.1186/s12906-017-1905-y. PMid:28789647.

9. Shiwa SR, Costa LOP, Moser ADL, Aguiar IC, de Oliveira LVF. PEDro: the physiotherapy evidence database. Fisioter Mov. 2011;24(3):523-33. http://dx.doi.org/10.1590/S0103-51502011000300017.

10. Tullberg M, Alstergren PJ, Ernberg MM. Effects of low-power laser exposure on masseter muscle pain and microcirculation. Pain. 2003;105(1–2):89-96. http://dx.doi.org/10.1016/S0304-3959(03)00166-0. PMid:14499424.

11. Ilbuldu E, Cakmak A, Disci R, Aydin R. Comparison of laser, dry needling, and placebo laser treatments in myofascial pain syndrome. Photomed Laser Surg. 2004;22(4):306-11. http://dx.doi.org/10.1089/pho.2004.22.306. PMid:15345173.

12. Medeiros JS, Vieira GF, Nishimura PY. Laser application effects on the bite strength of the masseter muscle, as an orofacial pain treatment. Photomed Laser Surg. 2005;23(4):373-6. http://dx.doi.org/10.1089/pho.2005.23.373. PMid:16144479.

13. Çetiner S, Kahraman SA, Yücetas ULE. Evaluation of low-level laser therapy in the treatment of temporomandibular disorders. Photomed Laser Surg. 2006;24(5):637-41. http://dx.doi.org/10.1089/pho.2006.24.637. PMid:17069496.

14. Sebbe TF, Pereira WG, Nicolau RA, Kelencz CA, Munoz IS, Pacheco MT, et al. Estudo eletromiográfico do efeito do laser de GAALAS (685 e 830nm) sobre o processo de fadiga de músculo masseter - estudo clínico. In: X Encontro Latino Americano de Iniciação Científica e VI Encontro Latino Americano de Pós-Graduação; 2006 Out; São José dos Campos. São José dos Campos: Universidade do Vale do Paraíba; 2006. 741-4.

15. Shinozaki EB, Paiva G, Zanin FAA, Brugnera A Jr. The electromyography evaluation in Temporomandibular joint disease patients after laser therapy. RGO. 2006;54(4):334-9.

16. Núñez SC, Garcez AS, Suzuki SS, Ribeiro MS. Management of mouth opening in patients with temporomandibular disorders through Low-Level Laser Therapy and transcutaneous electrical neural stimulation. Photomed Laser Surg. 2006;24(1):45-9. http://dx.doi.org/10.1089/pho.2006.24.45. PMid:16503788.

17. Kato MT, Kogawa EM, Santos CN, Conti PCR. TENS and low-level laser therapy in the management of temporomandibular disorders. J Appl Oral Sci. 2006;14(2):130-5. http://dx.doi.org/10.1590/S1678-77572006000200012. PMid:19089044.

18. Shirani AM, Gutknecht N, Taghizadeh M, Mir M. Low-level laser therapy and myofacial pain dysfunction syndrome : a randomized controlled clinical trial. Lasers Med Sci. 2009;24(5):715-20. http://dx.doi.org/10.1007/s10103-008-0624-5. PMid:19002646.

19. Öz S, Gökçen-Röhlig B, Saruhanoglu A, Tuncer EB. Management of myofascial pain : low-level laser therapy versus occlusal splints. J Craniofac Surg. 2010;21(6):1722-8. http://dx.doi.org/10.1097/SCS.0b013e3181f3c76c. PMid:21119408.

20. Shinozaki EB, Bertolini M, Okazaki LK, Marchini L, Junior AB. Clinical assessment of the efficacy of low-level laser therapy on muscle pain in women with temporomandibular dysfunction, by surface electromyography. Braz J Oral Sci. 2010;9(4):434-8.

21. Balestra CM, Oliveira JLR, Nicolau RA, Dias RSS. Análise termográfica da região de masseter após irradiação com laser ou LED – estudo clínico. ConScientiae Saúde. 2011;10(1):17-22. http://dx.doi.org/10.5585/conscientiaesaude/2011/v10n1/2415.

22. Kelencz CA, Muñoz ISS, Amorim CF, Nicolau RA. Effect of low-power gallium-aluminum-arsenium noncoherent light (640 nm) on muscle activity: a clinical study. Photomed Laser Surg. 2010;28(5):647-52. http://dx.doi.org/10.1089/pho.2008.2467. PMid:20961231.

23. Silva MAMR, Botelho AL, Turim CV, Silva AMBR. Low level laser therapy as an adjunctive technique in the management of temporomandibular disorders. Cranio. 2012;30(4):264-71. http://dx.doi.org/10.1179/crn.2012.040. PMid:23156967.

24. Gökçen-Röhlig B, Kipirdi S, Baca E, Keskin H, Sato S. Evaluation of orofacial function in temporomandibular disorder patients after low-level laser therapy. Acta Odontol Scand. 2013;71(5):1112-7. http://dx.doi.org/10.3109/00016357.2012.749517. PMid:23210731.

25. Carli ML, Guerra MB, Nunes TB, Matteo RC, Luca CEP, Aranha ACC, et al. Piroxicam and laser phototherapy in the treatment of TMJ arthralgia: a double-blind randomised controlled trial. J Oral Rehabil. 2013;40(3):171-8. http://dx.doi.org/10.1111/joor.12022. PMid:23252583.

26. Uemoto L, Garcia MAC, Gouvêa CVD, Vilella OV, Alfaya TA. Laser therapy and needling in myofascial trigger point deactivation. J Oral Sci. 2013;55(2):175-81. http://dx.doi.org/10.2334/josnusd.55.175. PMid:23748458.

27. Ahrari F, Madani AS, Ghafouri ZS, Tunér J. The efficacy of low-level laser therapy for the treatment of myogenous temporomandibular joint disorder. Lasers Med Sci. 2014;29(2):551-7. http://dx.doi.org/10.1007/s10103-012-1253-6. PMid:23318917.

28. Maia MLDM, Ribeiro MAG, Maia LGM, Stuginski-Barbosa J, Costa YM, Porporatti AL, et al. Evaluation of low-level laser therapy effectiveness on the pain and masticatory performance of patients with myofascial pain. Lasers Med Sci. 2014;29(1):29-35. http://dx.doi.org/10.1007/s10103-012-1228-7. PMid:23143142.

29. Madani A, Ahrari F, Fallahrastegar A, Daghestani N. A randomized clinical trial comparing the efficacy of low-level laser therapy (LLLT) and laser acupuncture therapy (LAT) in patients with temporomandibular disorders. Lasers Med Sci. 2020;35(1):181-92. http://dx.doi.org/10.1007/s10103-019-02837-x. PMid:31396794.

30. Nencheva-Svechtarova S, Svechtarov V, Gisbrecht A, Uzunov T. Clinical and experimental study of GaAlAs phototherapy for temporomandibular disorders. Acta Med Bulg. 2014;41(2):49-54. http://dx.doi.org/10.1515/amb-2014-0021.

31. Godoy CHL, Motta LJ, Steagall W Jr, Gonçalves MLL, Silva DFT, Mesquita-Ferrari RA, et al. Effect of phototherapy on masseter and anterior temporal muscles before induction of fatigue: a randomized, sham-controlled, blind clinical trial. Photomed Laser Surg. 2018;36(7):370-6. http://dx.doi.org/10.1089/pho.2017.4396. PMid:29768084.

32. Panhoca VH, Lizarelli RF, Nunez SC, Pizzo RC, Grecco C, Paolillo FR, et al. Comparative clinical study of light analgesic effect on temporomandibular disorder (TMD) using red and infrared led therapy. Lasers Med Sci. 2015;30(2):815-22. http://dx.doi.org/10.1007/s10103-013-1444-9. PMid:24197518.

33. Sumen A, Sarsan A, Alkan H, Yildiz N, Ardic F. Efficacy of low level laser therapy and intramuscular electrical stimulation on myofascial pain syndrome. J Back Musculoskelet Rehabil. 2015;28(1):153-8. http://dx.doi.org/10.3233/BMR-140503. PMid:25061034.

34. Cavalcanti MFXB, Silva UH, Leal-Junior ECP, Lopes-Martins RAB, Marcos RL, Pallotta RC, et al. Comparative study of the physiotherapeutic and drug protocol and low-level laser irradiation in the treatment of pain associated with temporomandibular dysfunction. Photomed Laser Surg. 2016;34(12):652-6. http://dx.doi.org/10.1089/pho.2016.4195. PMid:27898256.

35. Carli BMG, Magro AKD, Souza-Silva BN, Matos FS, Carli JP, Paranhos LR, et al. The effect of laser and botulinum toxin in the treatment of myofascial pain and mouth opening: a randomized clinical trial. J Photochem Photobiol B. 2016;159:120-3. http://dx.doi.org/10.1016/j.jphotobiol.2016.03.038. PMid:27045280.

36. Magalhães MT, Núñez SC, Kato IT, Ribeiro MS. Light therapy modulates serotonin levels and blood flow in women with headache. A preliminary study. Exp Biol Med. 2016;241(1):40-5. http://dx.doi.org/10.1177/1535370215596383. PMid:26202374.

37. Santos MTBR, Nascimento KS, Carazzato S, Barros AO, Mendes FM, Diniz MB. Efficacy of photobiomodulation therapy on masseter thickness and oral health-related quality of life in children with spastic cerebral palsy. Lasers Med Sci. 2017;32(6):1279-88. http://dx.doi.org/10.1007/s10103-017-2236-4. PMid:28536904.

38. Alayat MS, Elsoudany AM, Ali ME. Efficacy of multiwave locked system laser on pain and function in patients with chronic neck pain: a randomized placebo-controlled trial. Photomed Laser Surg. 2017;35(8):450-5. http://dx.doi.org/10.1089/pho.2017.4292. PMid:28783464.

39. Costa SAP, Florezi GP, Artes GE, Costa JR, Gallo RT, Freitas PM, et al. The analgesic effect of photobiomodulation therapy (830 nm) on the masticatory muscles: a randomized, double-blind study. Braz Oral Res. 2017;31(0):e107. http://dx.doi.org/10.1590/1807-3107bor-2017.vol31.0107. PMid:29267668.

40. Hosgor H, Bas B, Celenk C. A comparison of the outcomes of four minimally invasive treatment methods for anterior disc displacement of the temporomandibular joint. Int J Oral Maxillofac Surg. 2017;46(11):1403-10. http://dx.doi.org/10.1016/j.ijom.2017.05.010. PMid:28602569.

41. Kagan LS, Heaton JT. The effectiveness of Low-Level Light Therapy in attenuating vocal fatigue. J Voice. 2017;31(3):384-23. http://dx.doi.org/10.1016/j.jvoice.2016.09.004. PMid:27839705.

42. Rezazadeh F, Hajian K, Shahidi S, Piroozi S. Comparison of the effects of transcutaneous electrical nerve stimulation and low-level laser therapy on drug-resistant temporomandibular disorders. J Dent. 2017;18(3):187-92. PMid:29034273.

43. Santos MTBR, Diniz MB, Gouw-Soares SC, Lopes-Martins RAB, Frigo L, Baeder FM. Evaluation of Low-Level Laser Therapy in the treatment of masticatory muscles spasticity in children with cerebral palsy. J Biomed Opt. 2016;21(2):28001. http://dx.doi.org/10.1117/1.JBO.21.2.028001. PMid:26882450.

44. Brochado FT, Jesus LH, Carrard VC, Freddo AL, Chaves KD, Martins MD. Comparative effectiveness of photobiomodulation and manual therapy alone or combined in TMD patients: a randomized clinical trial. Braz Oral Res. 2018;32(0):e50. http://dx.doi.org/10.1590/1807-3107bor-2018.vol32.0050. PMid:29995062.

45. Godoy CHL, Motta LJ, Steagall W Jr, Gonçalves MLL, Silva DFT, Mesquita-Ferrari RA, et al. Effect of phototherapy on masseter ans anterior temporal muscles before induction of fatigue: a randomized, sham-controlled, blind clinical trial. Photomed Laser Surg. 2018;36(7):370-6. http://dx.doi.org/10.1089/pho.2017.4396. PMid:29768084.

46. Herpich CM, Leal-Junior ECP, Gomes CAFP, Gloria IPS, Amaral AP, Amaral MFRS, et al. Immediate and short-term effects of phototherapy on pain, muscle activity, and joint mobility in women with temporomandibular disorder: a randomized, double-blind, placebo-controlled, clinical trial. Disabil Rehabil. 2018;40(19):2318-24. http://dx.doi.org/10.1080/09638288.2017.1336648. PMid:28602137.

47. Lauriti L, Luz JGC, Mesquita-Ferrari RA, Fernandes KPS, Deana AM, Horliana ACRT, et al. Evaluation of the effect of phototherapy in patients with mandibular fracture on mandibular dynamics, pain, edema, and bite force: a pilot study. Photomed Laser Surg. 2018;36(1):24-30. http://dx.doi.org/10.1089/pho.2017.4334. PMid:29023221.

48. Mendonça FS, Carvalho PTC, Biasotto-Gonzalez DA, Calamita SAP, Gomes CAFP, Amorim CF, et al. Muscle fiber conduction velocity and EMG amplitude of the upper trapezius muscle in healthy subjects after low-level laser irradiation: a randomized, double-blind, placebo-controlled, crossover study. Lasers Med Sci. 2018;33(4):737-44. http://dx.doi.org/10.1007/s10103-017-2404-6. PMid:29204914.

49. Rasca E, Namour A, Fauchon-Giumelli A, Nammour S. Laser phototherapy in acute posttraumatic trismus – case-series study. Laser Ther. 2018;27(3):219-26. http://dx.doi.org/10.5978/islsm.27_18-OR-21. PMid:32158068.

50. Souza RC, Sousa ET, Scudine KG, Meira UM, Silva EMO, Gomes AC, et al. Low-level laser therapy and anesthetic infiltration for orofacial pain in patients with fibromyalgia: a randomized clinical trial. Med Oral Patol Oral Cir Bucal. 2018;23(1):e65-71. PMid:29274162.

51. Sveshtarov V, Nencheva-Sveshtarova S, Grozdanova R, Prodanova K. Superluminous devices versus low-level laser for temporomandibular disorders. Acta Med Bulg. 2018;45(1):11-5. http://dx.doi.org/10.2478/amb-2018-0002.

52. Király M, Bender T, Hodosi K. Comparative study of shockwave therapy and low-level laser therapy effects in patients with myofascial pain syndrome of the trapezius. Rheumatol Int. 2018;38(11):2045-52. http://dx.doi.org/10.1007/s00296-018-4134-x. PMid:30171341.

53. Mansourian A, Pourshahidi S, Sadrzadeh-Afshar MS, Ebrahimi H. A Comparative study of low-level laser therapy and transcutaneous electrical nerve stimulation as an adjunct to pharmaceutical therapy for myofascial pain dysfunction syndrome: a randomized clinical trial. Front Dent. 2019;16(4):256-64. PMid:32342054.

54. Chellappa D, Thirupathy M. Comparative efficacy of low-Level laser and TENS in the symptomatic relief of temporomandibular joint disorders: a randomized clinical trial. Indian J Dent Res. 2020;31(1):42-7. http://dx.doi.org/10.4103/ijdr.IJDR_735_18. PMid:32246680.

55. Shahimoridi D, Shafiei SA, Yousefian B. The effectiveness of the polarized low-level laser in the treatment of patients with myofascial trigger points in the trapezius muscles. J Lasers Med Sci. 2020;11(1):14-9. http://dx.doi.org/10.15171/jlms.2020.04. PMid:32099622.

56. Nadershah M, Abdel-Alim HM, Bayoumi AM, Jan AM, Elatrouni A, Jadu FM. Photobiomodulation therapy for myofascial pain in temporomandibular joint dysfunction: a double-blinded randomized clinical trial. J Maxillofac Oral Surg. 2020;19(1):93-7. http://dx.doi.org/10.1007/s12663-019-01222-z. PMid:31988570.

57. Madani AS, Ahrari F, Nasiri F, Abtahi M, Tunér J. Low-level laser therapy for management of TMJ osteoarthritis. J Cranio. 2014;32(1):38-44. http://dx.doi.org/10.1179/0886963413Z.0000000004. PMid:24660645.

58. Freitas LF, Hamblin MR. Proposed mechanisms of photobiomodulation or low-level light therapy. IEEE J Sel Top Quantum Electron. 2016;22(3):7000417. http://dx.doi.org/10.1109/JSTQE.2016.2561201. PMid:28070154.

59. Karu TI. Photobiological fundamentals of low-power laser therapy. IEEE J Quantum Electron. 1987;23(10):1703-17. http://dx.doi.org/10.1109/JQE.1987.1073236.

60. Karu T. Laser biostimulation: a photobiological phenomenon. J Photochem Photobiol B, Biol. 1989;3(4)638-40.

61. Alves VMN, Furlan RMMM, Motta AR. Immediate effects of photobiomodulation with low-level laser therapy on muscle performance: an integrative literature review. Rev CEFAC. 2019;21(4):e12019. http://dx.doi.org/10.1590/1982-0216/201921412019.

62. Cotler HB, Chow RT, Hamblin MR, Carrol J. The use of Low Level Laser Therapy (LLLT) For musculoskeletal pain. MOJ Orthop Rheumatol. 2015;2(5):00068. http://dx.doi.org/10.15406/mojor.2015.02.00068. PMid:26858986.

63. Hamblin MR. Mechanisms and mitochondrial redox signaling in photobiomodulation. Photochem Photobiol. 2018;94(2):199-212. http://dx.doi.org/10.1111/php.12864. PMid:29164625.