Research, Society and Development, v. 11, n. 5, e43111528463, 2022
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v11i5.28463

A comparative pilot study on the effects of laser and light-emitting diode therapy on pain in individuals with temporomandibular disorder

Um estudo piloto comparativo sobre os efeitos da terapia com laser e diodo emissor de luz na dor em indivíduos com disfunção temporomandibular

Un estudio piloto comparativo sobre los efectos de la terapia con láser y diodo emisor de luz sobre el dolor en personas con trastorno temporomandibular

Received: 03/24/2022 | Reviewed: 03/30/2022 | Accept: 04/05/2022 | Published: 04/12/2022

Luciana Gonçalves Langella
ORCID: https://orcid.org/0000-0002-6791-534X
University Nove de Julho, Brazil
E-mail: lucianalangella@hotmail.com
Andréa Oliver Gomes
ORCID: https://orcid.org/0000-0002-4515-3508
University Nove de Julho, Brazil
E-mail: an_oliver@hotmail.com
Tamiris da Silva
ORCID: https://orcid.org/0000-0003-2023-4798
University Nove de Julho, Brazil
E-mail: tamiris.slv@hotmail.com
Marcela Letícia Leal Gonçalves
ORCID: https://orcid.org/0000-0003-1305-5257
Unimes, Brazil
E-mail: marcelalleal@hotmail.com
Anna Carolina Ratto Tempestini Horliana
ORCID: https://orcid.org/0000-0003-3476-9064
University Nove de Julho, Brazil
E-mail: annacrth@hotmail.com
Lara Jansiski Motta
ORCID: https://orcid.org/0000-0002-7774-4345
University Nove de Julho, Brazil
E-mail: larajmotta@terra.com.br
Raquel Agnelli Mesquita-Ferrari
ORCID: https://orcid.org/0000-0001-5142-9526
University Nove de Julho, Brazil
E-mail: raquel.mesquita@gmail.com
Kristianne Porta Santos Fernandes
ORCID: https://orcid.org/0000-0001-7156-9286
University Nove de Julho, Brazil
E-mail: kristianneporta@gmail.com
Alessandro Melo Deana
ORCID: https://orcid.org/0000-0002-0014-6953
University Nove de Julho, Brazil
E-mail: amdeana@gmail.com
Sandra Kalil Bussadori
ORCID: https://orcid.org/0000-0002-9853-1138
University Nove de Julho, Brazil
E-mail: sandra.skb@gmail.com

Abstract

Temporomandibular disorder (TMD) is described as a subgroup of orofacial pain. Studies have demonstrated that phototherapy is an effective treatment option for TMD, leading to improvements in pain and orofacial function. To compare the effects of photobiomodulation with different light sources on pain and functioning in patients with TMD. Methods: A randomized, controlled, double-blind clinical trial (pilot study) was conducted with 15 individuals aged 18 years or older allocated to two photobiomodulation groups: laser and LED. Sessions were held twice a week for four weeks (total: eight sessions). The Research Diagnostic Criteria for Temporomandibular Disorders were used for the evaluation and Pain was measured using the Visual Analog Scale. Orofacial function was determined based on measures of mandibular movements. Photobiomodulation was administered to the temporomandibular joint, masseter (upper, middle and lower) and anterior temporal muscles. Results: Statistically significant differences in pain were

found in the intra-group analyses (pre-treatment vs. post-treatment) in both groups (laser: p=0.0117; LED: p=0.0180). Statistically significant intra-group differences were found for maximum mouth opening without assistance and maximum mouth opening with assistance in the laser group (p= 0.0203 and 0.0001, respectively). The same was found in the LED group only regarding maximum mouth opening with assistance (p=0.0459). Statistically significant intra-group differences (pre-treatment vs. post-treatment) were found for lateral excursion to both sides in the laser group (right side: p=0.0209; left side: p=0.0005) and only to the left side in the LED group (p=0.0342). Conclusion: Photobiomodulation with laser and LED produce similar effects regarding improvements in TMD.
Keywords: Temporomandibular disorder; Photobiomodulation; Low-level laser; Light-emitting diode (LED).

Resumo
A disfunção temporomandibular (DTM) é descrita como um subgrupo de dor orofacial. Estudos têm demonstrado que a fototerapia é uma opção de tratamento eficaz para DTM, levando a melhora da dor e da função orofacial. Comparar os efeitos da fotobiomodulação com diferentes fontes de luz na dor e funcionamento em pacientes com DTM. Métodos: Foi realizado um ensaio clínico randomizado, controlado e duplo-cego (estudo piloto) com 15 indivíduos com 18 anos ou mais alocados em dois grupos de fotobiomodulação: laser e LED. As sessões foram realizadas duas vezes por semana durante quatro semanas (total: oito sessões). Para a avaliação foram utilizados os Critérios Diagnósticos de Pesquisa para Disfunção Temporomandibular e a Dor foi mensurada por meio da Escala Visual Analógica. A função orofacial foi determinada com base nas medidas dos movimentos mandibulares. A fotobiomodulação foi administrada nos músculos da articulação temporomandibular, masseter (superior, médio e inferior) e temporal anterior. Resultados: Foram encontradas diferenças estatisticamente significativas na dor nas análises intragrupos (pré-tratamento vs. pós-tratamento) em ambos os grupos (laser: p=0,0117; LED: p=0,0180). Diferenças estatisticamente significativas intragrupos foram encontradas para abertura máxima da boca sem assistência e abertura máxima da boca com assistência no grupo laser (p= 0,0203 e 0,0001, respectivamente). O mesmo foi encontrado no grupo LED apenas em relação à abertura máxima da boca com auxílio (p=0,0459). Diferenças intragrupo estatisticamente significativas (pré-tratamento vs. pós-tratamento) foram encontradas para excursão lateral para ambos os lados no grupo laser (lado direito: p=0,0209; lado esquerdo: p=0,0005) e apenas para o lado esquerdo em o grupo LED (p=0,0342). Conclusão: A fotobiomodulação com laser e LED produz efeitos semelhantes na melhora da DTM.
Palavras-chave: Desordem temporomandibular; Fotobiomodulação; Laser de baixa potência; Diodo emissor de luz (LED).

Resumen
El trastorno temporomandibular (TMD) se describe como un subgrupo de dolor orofacial. Los estudios han demostrado que la fototerapia es una opción de tratamiento eficaz para el TMD, que mejora el dolor y la función orofacial. Comparar los efectos de la fotobiomodulación con diferentes fuentes de luz sobre el dolor y el funcionamiento en pacientes con TTM. Métodos: Se llevó a cabo un ensayo clínico aleatorizado, controlado, doble ciego (estudio piloto) con 15 sujetos de 18 años o más asignados a dos grupos de fotobiomodulación: láser y LED. Las sesiones se realizaron dos veces por semana durante cuatro semanas (total: ocho sesiones). Para la evaluación se utilizaron los Criterios Diagnósticos de Investigación para los Trastornos Temporomandibulares y el Dolor se midió mediante la Escala Visual Analógica. La función orofacial se determinó en base a las mediciones de los movimientos mandibulares. Se administró fotobiomodulación en la articulación temporomandibular, masetero (superior, medio e inferior) y músculos temporales anteriores. Resultados: Se encontraron diferencias estadísticamente significativas en el dolor en los análisis intragrupo (pretratamiento vs. postratamiento) en ambos grupos (láser: p=0,0117; LED: p=0,0180). Se encontraron diferencias intragrupo estadísticamente significativas para la apertura máxima de la boca sin asistencia y la apertura máxima de la boca con asistencia en el grupo de láser (p = 0,0203 y 0,0001, respectivamente). Lo mismo se encontró en el grupo LED solo en relación a la máxima apertura bucal con ayuda (p=0,0459). Se encontraron diferencias intragrupo estadísticamente significativas (pretratamiento vs. postratamiento) para la excursión lateral a ambos lados en el grupo de láser (lado derecho: p=0,0209; lado izquierdo: p=0,0005) y solo al lado izquierdo en el LED grupo (p=0,0342). Conclusión: La fotobiomodulación con láser y LED produce efectos similares en la mejora de la DTM.
Palabras clave: Trastorno temporomandibular; Fotobiomodulación; Láser de baja potencia; Diodo emisor de luz (LED).

1. Introduction

Temporomandibular disorder (TMD) is described as a subgroup of orofacial pain involving the temporomandibular joint (TMJ), masticatory muscles, ears and cervical spine either unilaterally or bilaterally (Leal de Godoy, 2013; Pereira, 2014; Salmos-Brito, 2013; IASP, 1994). Signs and symptoms include local pain, limitations of masticatory function, deviations of the mandible, and noises when opening/closing the mouth. TMD is common among adults and adolescents. The world

literature reports prevalence rates of 25-52% among adults and of 2-5% among adolescents. As is the case for headaches, TMD is slightly more common among women. TMD occurs in up to 14% of women and 10% of men (Lövgren, 2016).

It has been well established that primary headaches (especially migraine, chronic migraine, and tension-type headache) and temporomandibular dysfunction (TMD) are comorbid diseases, with the presence of one of them in a patient increasing the prevalence of the others. The relationship between the 2 diseases may involve the sharing of common physiopathological aspects (Mongini, 2007; Bevilaqua, 2009; Bender, 2014; Speciali, 2015).

The symptoms of TMD, especially pain, can affect the quality of life of patients by imposing limitations on activities of daily living, such as laughing, eating, speaking and yawning (Leal de Godoy, 2013; Gonçalves, 2010; Dworkin, 1990). Due to the pain and functional limitations inherent to this condition, photobiomodulation (PBM) has been investigated as a treatment option for cases of TMD throughout the years (Mazzetto, 2007; Mazzetto, 2010; Petrucci, 2011; Salmos-Brito, 2013; Pereira, 2014; Brochado, 2018; Tunér, 2019; Herpich, 2020; Nadershah,2020).

Therefore, the aim of the present study was to compare the effects of photobiomodulation with different light sources (laser and LED) on pain and functioning in patients with TMD.

2. Methodology

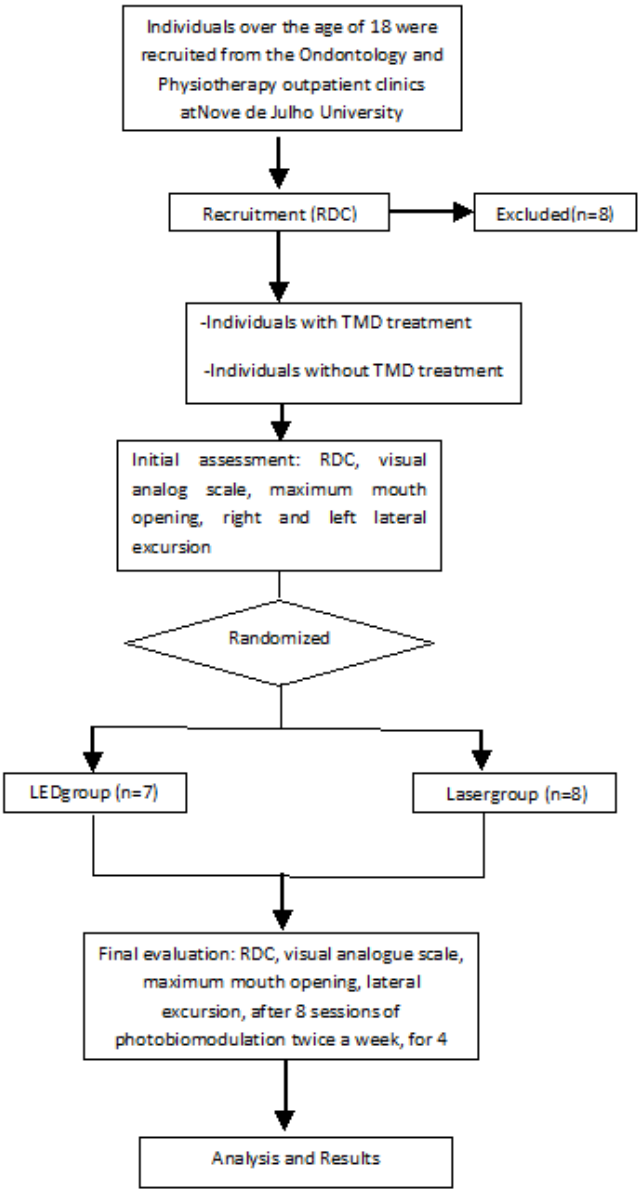
Study design and ethics statement

A randomized clinical trial (pilot) was conducted at the Integrated Health Laboratory as well as the dentistry and physical therapy clinics of University Nove de Julho. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (Human Research Ethics Committee of the University Nove de Julho, São Paulo, in Brazil, protocol number 1.706.160 and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. It has also been registered with ClinicalTrials.gov (NCT03257748). The methodology was based on a previously published protocol (21).

Characterization of sample

The study involved the participation of a convenience sample of 15 women aged 18 years or older with a diagnosis of TMD who agreed to participate by signing a statement of informed consent. Fig. 1 shows the flowchart of the study design in accordance with the Consolidated Standards of Reporting Trials (CONSORT) statement.

Figure 1. Flowchart.



Source: Authors.

Randomization

The participants were randomly allocated to two groups (laser and LED) by a simple lottery method (A and B). Using a randomization table at a central office, the labels were placed in opaque envelopes, which were sealed and numbered to ensure confidentiality. The same researcher generated the random allocation sequence, enrolled participants, and assigned participants to interventions.

Inclusion criteria

Individuals aged 18 years or older with at least 20 functional teeth (at least three molars) and a diagnosis of TMD based on the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) were recruited for the study (Dworkin, 1992).

Exclusion criteria

Dental-facial deformities, use of a fixed or removable orthodontic appliance, use of muscle relaxants during the experimental period, neurological diseases and cognitive deficits that would impede the evaluations.

Evaluations

Research Diagnostic Criteria for Temporomandibular Disorders

The participants were diagnosed using the RDC/TMD questionnaire, which consists of a clinical examination involving palpation of the temporal, masseter, digastric and medial pterygoid muscles, palpation of the TMJs and an analysis of the mandible using digital calipers for the measurement of vertical and horizontal movements and a stethoscope for the determination of joint sounds. Next, symptoms were investigated, such as the occurrence of headache, facial pain, fatigue and difficulty when chewing, bruxism, psychological state and parafunctional habits (Langella, 2018; Dworkin, 1992). The clinical examination was performed by a single examiner who had undergone training exercises.

Assessment of pain

Pain intensity was measured using the Visual Analog Scale (VAS), which ranges from 0 (absence of pain) to 10 (worst pain ever experienced). The volunteers were instructed to mark the number that best represented their perception of pain during palpation of the masseter and anterior temporal muscles. This procedure was performed before and after the four-week treatment protocol. This is the primary outcome of the study.

Maximum mouth opening

The volunteers were instructed to perform maximum voluntary mouth opening (distance between maxillary and mandibular central incisors), which was measured with the aid of calipers. The volunteers were instructed to exert pressure on the mandibular teeth and move the mandible to the left and right for the determination of lateral excursion (distance between the maxillary and mandibular midpoints). These procedures were performed before and after the four-week treatment protocol (secondary outcome).

Intervention

Irradiation protocol

After recruitment, the volunteers were randomly allocated to two groups: Laser and LED therapy. Sessions were held twice a week for four weeks (total: eight sessions). Evaluations were performed before (pre-treatment) and 24 hours after the last treatment session (post-treatment). Neither the participants, nor the outcome assessor knew to which group the individuals belonged, assuring the double-blindness. As both groups were irradiated, participants did not know whether they were receiving LED or laser applications.

Laser

Low-intensity laser was administered using a gallium-aluminum-arsenide **(**GaALAs) device (Twin Flex Evolution®, MM Optics) in a reserved room. During treatment, both the patient and researcher used protective eyewear. The volunteer remained seated during the intervention. Irradiation was applied in the form of a zone using a device created to mimic the LED plate with three circles forming an intersection covering the side of the face. The laser tip was placed at a distance of 8 cm to encompass the area surrounding the TMJ as well as the anterior temporal and masseter (upper, middle and lower) muscles (Figure 2). Irradiation was administered bilaterally.

Figure 2. Illustration of the device designed for irradiation of the low intensity laser.

Source: Authors.

Light-emitting diode (LED)

LED treatment was performed with an infrared device (Linealux®, CosMedical) in a reserved room. During treatment, both the patient and researcher used protective eyewear. The volunteer remained seated during the intervention. The device has 36 infrared diodes coupled to a rectangular plate measuring 10 x 12 cm, which was attached to the side of the face with an elastic strap to encompass the area surrounding the TMJ as well as the anterior temporal and masseter (upper, middle and lower) muscles (Figure 3). Irradiation was administered bilaterally.

Figure 3. Illustration of LED board on patient during treatment.

Source: Authors.

Table 1. Irradiation parameters.

Parameters	Laser Group	LED Group
Central Wavelength	780 nm	780 nm
Target area	130 cm²	130 cm²
Beam area at aperture	0,226 cm²	3.58 cm²
Beam area at target	43.3 cm²	3.58 cm²
Radiant power	60 mW	5 mW
Total Exposure Time	600 s	600 s
Irradiated sites	3	36
Energy per point	36 J	3 J
Total energy	108 J	108 J
Radiant exposure	0,8 J/cm²	0,8 J/cm²
Irradiance	1,38 mW/cm²	1,38 mW/cm²

Source: Authors.

Statistical Methods

Descriptive statistics were performed for the characterization of the sample. The Shapiro-Wilk test was used to determine the normality of the data. Parametric data were expressed as mean and standard deviation values. Non-parametric data were expressed as median, maximum and minimum values. The Mann-Whitney test was used for the comparison of the effects of PBM on pain and orofacial function between groups. The Wilcoxon test was for the intra-group analyses (pre-treatment vs. post-treatment). All analyses were performed with the aid of the Statistical Package for the Social Sciences (SPSS15.0 for Windows), with the level of significance set to 5% ($p < 0.05$).

3. Results and Discussion

Table 2. Characterization of the sample.

	Gender	Age	VAS	
			Before	**After**
Group I	Female n = 8	24 ± 2,5	5 (5 – 7)	0,75 (0 – 3)
Group II	Female n = 7	24,9 ± 2,4	5 (4 – 7)	0,5 (0 – 3)

Source: Authors.

Table 2 displays the characteristics of the sample, regarding age and VAS values before and after treatment.

Table 3 displays the variables related to orofacial function during the pre-treatment and post-treatment evaluations with respective p-values. Regarding pain, significant differences were found in the intra-group (pre-treatment vs. post-treatment) analyses (laser: p=0.0117; LED: p=0.0180), whereas no significant difference was found in the inter-group analysis (Figure 4).

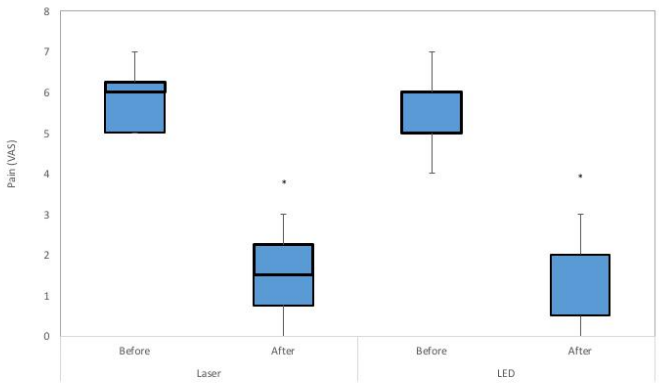
Table 3. Comparative analysis of variables.

	LASER Group			**LED Group**		
	Before	After	P Value	Before	After	P Value
EVA	5 (5 – 7)	0,75 (0 – 3)	0,0117*	5 (4 – 7)	0,5 (0 – 3)	0,0180*
Opening without pain-free aid	34,1 ± 13,2	39,1 ±8,3	0,1488	36,6 ± 11,8	44,7 ± 6,4	0,0543*
Maximum opening without aid	43,9 ± 9,9	48,0 ± 10,0	0,0203*	48,3 ± 7,2	48,9 ± 6,9	0,3208
Opening with aid	47,5 ± 9,5	50,6 ± 9,3	0,0001*	51,6 ± 6,7	54,6 ± 7,2	0,0459*
Rightside tour	10,0 ± 3,5	12,6 ± 2,9	0,0209*	11,0 ± 4,0	11,7 ± 3,0	0,3559
Leftside tour	10,9 ± 3,3	14,8 ± 3,3	0,0005*	9,4 ± 3,7	11,7 ± 2,6	0,0342*

Source: Authors.

In Figure 4, the effects of photobiomodulation therapy on pain using VAS between the laser and LED groups is described. It shows that pain was significantly reduced after the treatments in both groups.

Figure 4. Comparative analysis of the effects of photobiomodulation therapy on pain using Visual Analog Scale (p = 0.0117) and LED (p = 0.0180).

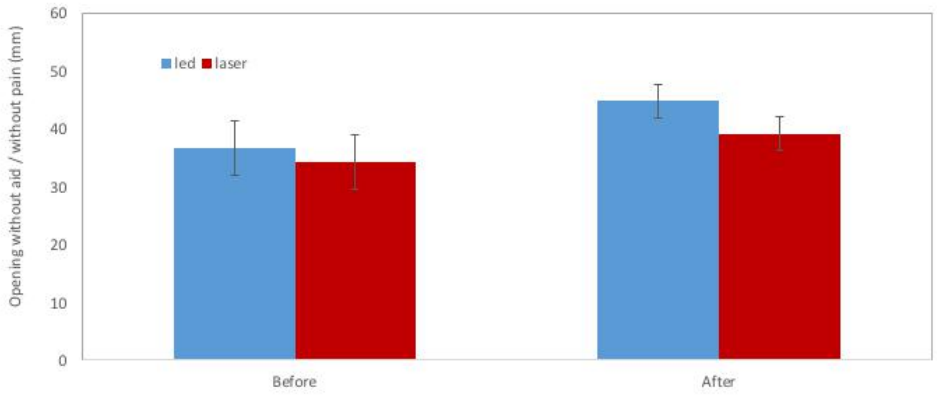


Source: Authors.

No statistically significant differences in maximum mouth opening without assistance and without pain were found in the intra-group analyses (pre-treatment vs. post-treatment) in either group (Figure 5). Statistically significant intra-group differences were found for maximum mouth opening without assistance and maximum mouth opening with assistance in the

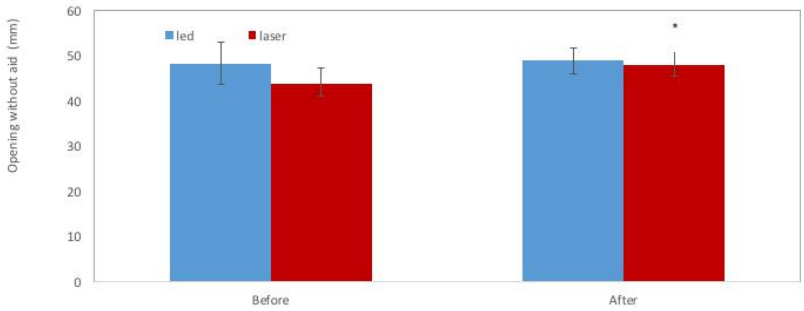
laser group (p = 0.0203 and 0.0001, respectively) (Figures 6 and 7). The same was found in the LED group only with regard to maximum mouth opening with assistance (p = 0.0459). In contrast, no statistically significant differences were found in the inter-group analysis.

Figure 5. Comparative analysis of the unaided and painless opening in the Laser group(p = 0, 1488) and LED (p = 0, 0543) and between both resources (p = 0, 712).



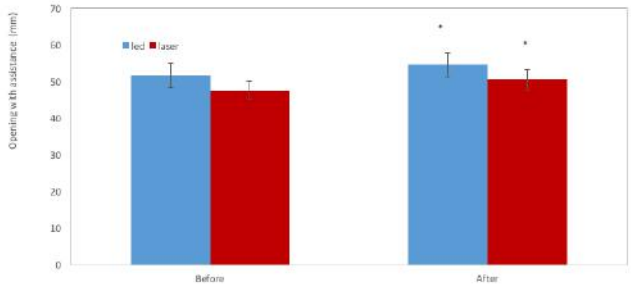
Source: Authors.

Figure 6. Comparative data of the maximal unaided aperture between groups (p = 0.3402) and pre and post treatment with laser photobiomodulation (p = 0.0203) and LED (p = 0.3208).



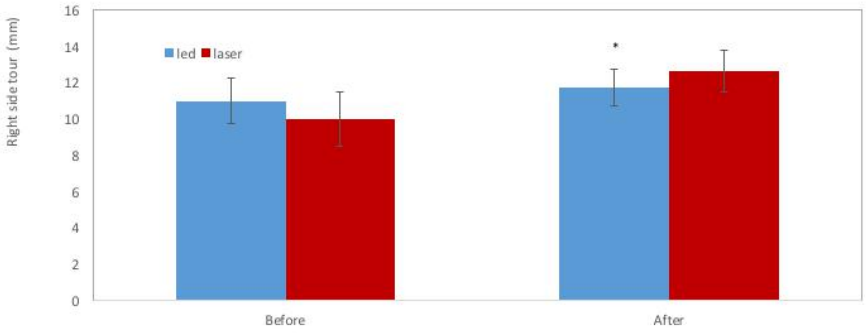
Source: Authors.

Figure 7. Comparison of maximum aperture data with aid between groups(p = 0.3515) and pre and post treatment for laser group (p = 0.0001) and LED group (p = 0.0459).



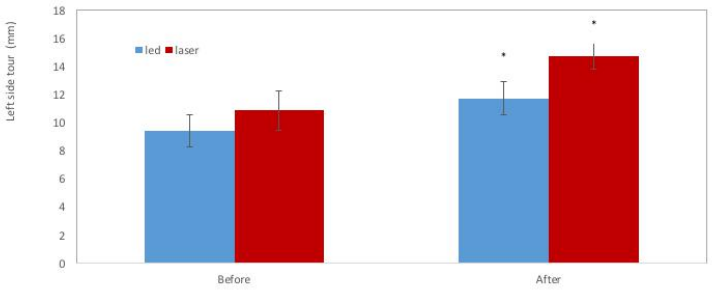
Source: Authors.

Figure 8. Comparison of right lateral excursion between groups (p = 0.6182) and pre and post treatment for laser group (p = 0.0209) and LED group (0.359).



Source: Authors.

Figure 9. Data from the comparative analysis for left lateral excursion between groups (p = 0.04433) and pre and post treatment for laser group (p = 0.0005) and LED group (0.0342).



Source: Authors.

Statistically significant intra-group differences (pre-treatment vs. post-treatment) were found for lateral excursion to both sides in the laser group (right side: p = 0.0209; left side: p = 0.0443) and only to the left side in the LED group (p = 0.0342) (Figures 8 and 9). In contrast, no statistically significant differences were found in the inter-group analysis. No harm was reported in either groups.

Discussion

This is the first study to compare PBM with laser to PBM with LED. Fifteen women with TMD were evaluated and we found positive results, with significant reductions in pain (analyzed using the VAS) after eight sessions of PBM in both groups. The group submitted to laser therapy demonstrated significant improvements in orofacial function with regard to maximum mouth opening without assistance, maximum mouth opening with assistance and both right and left lateral excursion. The group submitted to LED therapy demonstrated improvements in maximum mouth opening with assistance and left lateral excursion. No inter-group differences were found between laser and LED for any of the analyzed variables, suggesting that LED is a viable treatment option for controlling pain in patients with TMD.

TMD is an important cause of orofacial pain that implies a significant reduction in quality of life during functional activities, such as chewing, speaking and laughing (Leal de Godoy, 2013; Gonçalves, 2010; Dworkin, 1990). Therapies that control pain and normalize muscle function are needed for this population. PBM is a non-pharmacological, noninvasive, low-cost modality that has demonstrated favorable results in controlling TMD-related pain (Salmos-Brito, 2013; Mazzetto, 2007; Mazzetto, 2010; Tunér, 2019; Nadershah, 2019; Carvalho, 2010; Panhoca, 2015; Fikachova, 2007).

The use of PMB with the aim of reestablishing orofacial function has been explored in the literature and studies have reported statistically significant differences in maximum mouth opening and lateral excursion following the administration of low-level laser therapy (Salmos-Brito, 2013; Mazzetto, 2010; Panhoca, 2015; Shirani, 2009). The present study contributes further evidence of such effects.

Dostalová et al. (2012) found a significant improvement in pain (approximately 15%) measured using the VAS. In the present study, the reduction in pain using the same scale was approximately 10% after PBM with laser and LED. In a study involving individuals with myogenic TMD determined based on the RDC/TMD, Salmos-Brito et al. (2013) found significant improvements in pain (evaluated using the VAS) and orofacial function (measured by maximum mouth opening) after the use of PBM with low-level laser.

A recent randomized, placebo-controlled, double-blind, clinical trial compared the effectiveness of three different dosimetric PBM protocols for the treatment of patients with TMD. Pain, the severity of symptoms and joint mobility were evaluated before and after ten sessions. All dosimetric protocols proved effective at reducing pain and the severity of symptoms, but only the group submitted to AlGaAs laser (830 nm) at a power density of 30 mW/cm² and dose of 8J/cm² led to an increase in maximum mouth opening and protrusion of the mandible (Dostalová, 2012).

Research involving therapeutic LED has been growing in recent years. Studies report the beneficial analgesic and anti-inflammatory effects of LED therapy, demonstrating pain relief and improved function (Leal-Junior, 2009; Costa, 2021). However, few previous studies investigated the effects of this modality in patients with TMD (Panhoca, 2015; Vinck, 2003). In light of this, the aim of the present study was to compare laser and LED therapy with the same parameters. To increase the comparative power, we measured the distance required between the output of the laser aperture to the irradiated region until achieving the same area as that irradiated using the LED device. The other parameters (irradiation time, total energy irradiated, irradiance and irradiant exposure) were the same in the two protocols to ensure a lack of differences between the two modalities and enable the determination of the effectiveness of both light sources for the treatment of TMD.

Comparing the present investigation to the study conducted by Panhoça et al. (2015), similarities are found in the outcomes, although the PMB parameters were different. These similarities may be explained by the fact that both studies employed the same frequency of treatments as well as the influence LED therapy exerts on the reduction in nerve conduction, as described by Vinck et al. (2003), contributing to a reduction in orofacial pain, interrupting the pain-spasm-pain cycle and enabling the recovery of function.

A very recent study by Costa et al. (2021) compared the effects of LED therapy associated with occlusal splint (OS), a very common conventional treatment, on the signs and symptoms of TMD (Vinck, 2003). An infrared LED, such as the one used in the present study, was used on its own and in association with OS, in protocols that were conducted once or twice a week. They came to the conclusion that the association of LED therapy and OS presented superior results in relation to the isolated therapies, especially the protocol with two weekly sessions. This suggestes that the association of our protocol with other treatment forms could also achieve greater results.

In the present pilot study, LED proved to be effective for the treatment of TMD-related pain, with no significant differences in the comparison of the effects of low-level laser. Thus, LED is a viable alternative to laser therapy due the possibility of irradiating a larger area at a lower cost, which facilitates access to treatment by a larger portion of the population.

The main limitation of the present study was the sample size. Moreover, the results with regard to orofacial function following treatment with LED were not as clear as they could have been, as significant differences were only found for maximum mouth opening with assistance and left lateral excursion. Future studies should invest in LED therapy to determine the effects of other irradiation parameters and consolidate the use of this modality for pain relief and improvements in orofacial function in individuals with TMD.

4. Conclusion

Photobiomodulation with laser and LED produce similar effects on pain and orofacial function in individuals with temporomandibular disorder. Thus, LED therapy is a promising treatment modality for this population.

HIGHLIGHTS/CLINICAL RESEARCH

- Photobiomodulation with laser and LED produce similar effects on pain and orofacial function in individuals with TMD.
- LED therapy is a promising treatment modality for TMD.
- Future studies should invest in LED therapy for the treatment of TMD.

Acknowledgments

The authors thank University Nove de Julho for the making the laboratories available for the present study.

References

Baroni, B. M., Leal Junior, E. C. P., Geremia, J. M., Diefenthaeler, F., & Vaz, M. A. (2010). Effect of light-emitting diodes therapy (LEDT) on knee extensor muscle fatigue. *Photomedicine and laser surgery*, *28*(5), 653-658.

Bender, S. D. (2014). Orofacial pain and headache: a review and look at the commonalities. *Current pain and headache reports*, *18*(3), 1-6.

Brochado, F. T., Jesus, L. H. D., Carrard, V. C., Freddo, A. L., Chaves, K. D., & Martins, M. D. (2018). Comparative effectiveness of photobiomodulation and manual therapy alone or combined in TMD patients: a randomized clinical trial. *Brazilian Oral Research*, *32*.

Carvalho, C. M., de Lacerda, J. A., dos Santos Neto, F. P., Cangussu, M. C. T., Marques, A., & Pinheiro, A. L. (2010). Wavelength effect in temporomandibular joint pain: a clinical experience. *Lasers in medical science*, *25*(2), 229-232.

Costa, D. R., Pessoa, D. R., Seefeldt, V. B., Costa, D. R., Maia, D. T. L., dos Santos Maciel, T., ... & Nicolau, R. A. (2021). Orofacial evaluation of individuals with temporomandibular disorder after LED therapy associated or not of occlusal splint: a randomized double-blind controlled clinical study. *Lasers in medical science*, *36*(8), 1681-1689.

De Godoi Gonçalves, D. A., Dal Fabbro, A. L., Campos, J. A. D. B., Bigal, M. E., & Speciali, J. G. (2010). Symptoms of temporomandibular disorders in the population: an epidemiological study. *Journal of orofacial pain*, *24*(3).

Dostalová, T., Hlinakova, P., Kasparova, M., Rehacek, A., Vavrickova, L., & Navrátil, L. (2012). Effectiveness of physiotherapy and GaAlAs laser in the management of temporomandibular joint disorders. *Photomedicine and laser surgery*, *30*(5), 275-280.

Dworkin, S. F., Huggins, K. H., LeResche, L., Von Korff, M., Howard, J., Truelove, E., & Sommers, E. (1990). Epidemiology of signs and symptoms in temporomandibular disorders: clinical signs in cases and controls. *The Journal of the American Dental Association*, *120*(3), 273-281.

Fikácková, H., Dostálová, T., Navrátil, L., & Klaschka, J. (2007). Effectiveness of low-level laser therapy in temporomandibular joint disorders: a placebo-controlled study. *Photomedicine and laser surgery*, *25*(4), 297-303.

Grossi, D. B., Lipton, R. B., & Bigal, M. E. (2009). Temporomandibular disorders and migraine chronification. *Current pain and headache reports*, *13*(4), 314-318.

Herpich, C. M., Leal-Junior, E. C. P., Politti, F., de Paula Gomes, C. A. F., dos Santos Glória, I. P., de Souza Amaral, M. D. F. R., ... & Biasotto-Gonzalez, D. A. (2020). Intraoral photobiomodulation diminishes pain and improves functioning in women with temporomandibular disorder: a randomized, sham-controlled, double-blind clinical trial. *Lasers in medical science*, *35*(2), 439-445.

Langella, L. G., Silva, P. F., Costa-Santos, L., Gonçalves, M. L., Motta, L. J., Deana, A. M., ... & Bussadori, S. K. (2018). Photobiomodulation versus light-emitting diode (LED) therapy in the treatment of temporomandibular disorder: study protocol for a randomized, controlled clinical trial. *Trials*, *19*(1), 1-7.

Leal Junior, E. C. P., Lopes-Martins, R. A. B., Baroni, B. M., De Marchi, T., Rossi, R. P., Grosselli, D., ... & Bjordal, J. M. (2009). Comparison between single-diode low-level laser therapy (LLLT) and LED multi-diode (cluster) therapy (LEDT) applications before high-intensity exercise. *Photomedicine and laser surgery*, *27*(4), 617-623.

Leal Junior, E. C. P., Lopes-Martins, R. Á. B., Rossi, R. P., De Marchi, T., Baroni, B. M., De Godoi, V., ... & Bjordal, J. M. (2009). Effect of cluster multi-diode light emitting diode therapy (LEDT) on exercise-induced skeletal muscle fatigue and skeletal muscle recovery in humans. *Lasers in Surgery and Medicine: The Official Journal of the American Society for Laser Medicine and Surgery*, *41*(8), 572-577.

Leal de Godoy, C. H., da Costa Silva, P. F., Sales de Araujo, D., Motta, L. J., Biasotto-Gonzalez, D. A., Politti, F., ... & Bussadori, S. K. (2013). Evaluation of effect of low-level laser therapy on adolescents with temporomandibular disorder: study protocol for a randomized controlled trial. *Trials*, *14*(1), 1-6.

LeResche, L., & Von Korff, M. R. (1992). Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. *J craniomandib Disord*, *6*(4), 301-355.

Lövgren, A., Häggman-Henrikson, B., Visscher, C. M., Lobbezoo, F., Marklund, S., & Wänman, A. (2016). Temporomandibular pain and jaw dysfunction at different ages covering the lifespan–a population based study. *European Journal of Pain*, *20*(4), 532-540.

Mazzetto, M. O., Carrasco, T. G., Bidinelo, E. F., Pizzo, R. C. D. A., & Mazzetto, R. G. (2007). Low intensity laser application in temporomandibular disorders: a phase I double-blind study. *CRANIO®*, *25*(3), 186-192.

Mazzetto, M. O., Hotta, T. H., & Pizzo, R. C. D. A. (2010). Measurements of jaw movements and TMJ pain intensity in patients treated with GaAlAs laser. *Brazilian dental journal*, *21*, 356-360.

Merskey, H. E. (1986). Classification of chronic pain: Descriptions of chronic pain syndromes and definitions of pain terms. *Pain*.

Miranda, E. F., Vanin, A. A., Tomazoni, S. S., Grandinetti, V. D. S., de Paiva, P. R. V., Machado, C. D. S. M., ... & Leal-Junior, E. C. P. (2016). Using pre-exercise photobiomodulation therapy combining super-pulsed lasers and light-emitting diodes to improve performance in progressive cardiopulmonary exercise tests. *Journal of Athletic Training*, *51*(2), 129-135.

Mongini, F. (2007). Temporomandibular disorders and tension-type headache. *Current pain and headache reports*, *11*(6), 465-470.

Nadershah, M., Abdel-Alim, H. M., Bayoumi, A. M., Jan, A. M., Elatrouni, A., & Jadu, F. M. (2020). Photobiomodulation therapy for myofascial pain in temporomandibular joint dysfunction: a double-blinded randomized clinical trial. *Journal of Maxillofacial and Oral Surgery*, *19*(1), 93-97.

Panhoca, V. H., de Fatima Zanirato Lizarelli, R., Nunez, S. C., Pizzo, R. C. D. A., Grecco, C., Paolillo, F. R., & Bagnato, V. S. (2015). Comparative clinical study of light analgesic effect on temporomandibular disorder (TMD) using red and infrared led therapy. *Lasers in medical science*, *30*(2), 815-822.

Paolillo, F. R., Milan, J. C., Aniceto, I. V., Barreto, S. G., Rebelatto, J. R., Borghi-Silva, A., ... & Bagnato, V. S. (2011). Effects of infrared-LED illumination applied during high-intensity treadmill training in postmenopausal women. *Photomedicine and Laser Surgery*, *29*(9), 639-645.

Pereira, T. S., Flecha, O. D., Guimarães, R. C., Oliveira, D. D. D., Botelho, A. M., Glória, J. C. R., & Tavano, K. T. A. (2014). Efficacy of red and infrared lasers in treatment of temporomandibular disorders—a double-blind, randomized, parallel clinical trial. *Cranio®*, *32*(1), 51-56.

Pereira, T. S., Flecha, O. D., Guimarães, R. C., Oliveira, D. D. D., Botelho, A. M., Glória, J. C. R., & Tavano, K. T. A. (2014). Efficacy of red and infrared lasers in treatment of temporomandibular disorders - a double-blind, randomized, parallel clinical trial. *Cranio®*, *32*(1), 51-56.

Petrucci, A., Sgolastra, F., Gatto, R., Mattei, A., Monaco, A. (2011). Effectiveness of lowlevel laser therapy in temporomandibular disorders: a systematic review and meta-analysis. *J Orofac Pain*, 25(4):298–307.

Salmos-Brito, J. A. L., de Menezes, R. F., Teixeira, C. E. C., Gonzaga, R. K. M., Rodrigues, B. H. M., Braz, R., ... & de Martínez Gerbi, M. E. M. (2013). Evaluation of low-level laser therapy in patients with acute and chronic temporomandibular disorders. *Lasers in medical science*, *28*(1), 57-64.

Speciali, J. G., & Dach, F. (2015). Temporomandibular dysfunction and headache disorder. *Headache: The Journal of Head and Face Pain*, *55*, 72-83.

Shirani, A. M., Gutknecht, N., Taghizadeh, M., & Mir, M. (2009). Low-level laser therapy and myofacial pain dysfunction syndrome: a randomized controlled clinical trial. *Lasers in medical science*, *24*(5), 715-720.

Tunér, J., Hosseinpour, S., & Fekrazad, R. (2019). Photobiomodulation in temporomandibular disorders. *Photobiomodulation, photomedicine, and laser surgery*, *37*(12), 826-836.

Vinck, E. M., Cagnie, B. J., Cornelissen, M. J., Declercq, H. A., & Cambier, D. C. (2003). Increased fibroblast proliferation induced by light emitting diode and low power laser irradiation. *Lasers in medical science*, *18*(2), 95-99.