Original Research Article

Evaluation of the effect of vascular photobiomodulation in sleep bruxism of children and adolescents: A randomized controlled clinical trial

ABSTRACT

Objective: To assess the effect of the vascular photobiomodulation, also known as intravascular laser irradiation of blood (ILIB), combined with myofunctional exercises for the treatment of sleep bruxism in children and adolescents through a randomized controlled clinical trial. **Materials and methods:** Forty-six individuals with a diagnosis of bruxism between three and seventeen years of age were included. The participants were assessed before and after treatment with the aid of questionnaires addressing sleep bruxism and sleep quality as well as the measure of nocturnal oxygen saturation. The participants were divided into two groups: G1 (ILIB) and G2 (control). G1 received active ILIB combined with an orofacial myofunctional exercise protocol. G2 received sham ILIB and the exercise protocol. Ten-minute active/sham laser sessions were held at a frequency of once a week for four weeks. After each active/sham laser session, myofunctional therapy was performed and the participants were instructed to continue the exercises for five minutes twice a day. **Results:** Improvements were found in swallowing, breathing, and chewing among all patients in both groups, with no significant difference between groups. The reduction in bruxism was significantly greater ($p < 0.05$) in G1 (ILIB) compared to G2 (control). A weak to nil linear relationship between bruxism and oxygen saturation was found in both groups. **Conclusion:** ILIB favored a reduction in bruxism but was not decisive in improving orofacial functions, such as breathing, swallowing, and chewing. However, orofacial myofunctional therapy was effective at reducing conditions related to this sleep disorder.

Keywords: Bruxism; Intravascular Irradiation of Blood; Myofunctional Therapy; Oximetry; Photobiomodulation.

1. INTRODUCTION

Sleep bruxism (SB) was considered a disorder related to tooth wear and other occlusal characteristics and part of the micro-arousal phenomenon (waking for short periods during sleep). Recently, however, neurological and central associations have been investigated and bruxism is no longer considered an activity that emerges from occlusal interferences [1]. SB is currently considered masticatory muscle activity during sleep with rhythmic (phasic) or non-rhythmic (tonic) characteristics [2], altering the conception of SB as a parafunction (activity parallel to masticatory function) and understanding it to be a behavior with possible negative consequences [3].

The prevalence of SB among children and adolescents ranges from 3% to 49% [4]. This condition in children and adolescents can have negative consequences if not identified and treated in a timely manner. The most common symptoms are pain in the temporomandibular joint, masticatory muscles and neck muscles, headache, noise due to the grinding of the teeth, earache, tooth hypersensitivity, a lack of rest, and a consequent sensation of fatigue [5,6,7]. The etiology of SB is multifactorial, as the condition may be associated with an altered breathing pattern and poor sleep quality [8], genetic causes, such as possible polymorphisms, anxiety, some personality traits, and stress-related endocrine changes [9, 10].

The diagnosis of SB is established based on grinding or clenching the teeth during sleep, abnormal tooth wear, sounds related to bruxism, and discomfort in jaw muscles [9]. According to the 2018 consensus, possible SB is based only on the report of the patient or parents/guardians and probable BS is based on any of the clinical signs, with or without a positive report from the patient or guardians [3]. Polysomnography (PSG) is the 'gold standard' for the diagnosis of definite SB, as this method enables the simultaneous monitoring of electroencephalographic, electrocardiographic, and respiratory signs during sleep [11]. However, due to the high cost of PSG, self-administered questionnaires (completed by parents or guardians for pediatric patients) are generally used, with the diagnosis established based on the criteria recommended by the American Sleep Medicine Association [12,13].

Therapeutic options for SB are generally palliative, involving the treatment of symptoms without addressing the genesis of the behavior. Evidence on the effectiveness of medications for children and adolescents is scarce [14]. Physiotherapeutic treatments are considered a non-invasive option for the treatment of bruxism. In many cases, physiotherapy can prevent the need for invasive procedures and even the use of medication. Treatment ranges from educational guidelines focused on care and practices to inhibit parafunctional habits to exercises that help relax the masticatory muscles [15].

Bruxism has often been associated with sleep disturbances, abnormal movements, breathing difficulties, and increased muscle activity. However, the exact cause of the disorder remains complex and should be studied further. A literature review of 40 articles published from 2014 to 2021 described prevalence rates in children from 13 to 49%, with the diagnosis based primarily on observation, clinical history, and examination. Recommended treatments included physiotherapy and psychotherapy [16].

There is insufficient evidence to recommend a protocol for the treatment of SB for children and adolescents. Thus, new studies with standardized diagnostic methods, representative samples, and the presence of control groups must be carried out to gain a better understanding of the effectiveness of treatment for SB in children and adolescents. The choice for conservative treatments based on diagnosis and the management of risk factors as well as sleep hygiene seems to be the therapy of choice. The indications, contraindications, and side effects of the administration of drugs, medicinal extracts, and use of occlusal splints must be assessed on an individual basis [17].

Orofacial myofunctional therapy (MFT) and the intravascular laser irradiation of blood (ILIB) seem to be promising for the treatment of SB. Orofacial (MFT) consists of a set of techniques and procedures aimed at promoting changes in muscle patterns through isotonic and isometric exercises for orofacial and oropharyngeal muscles to enable improvements in the functions of breathing, chewing, swallowing, and speech [18]. Thus, orofacial MFT offers the possibility of modulating postural habits and some behavioral aspects that can directly affect SB.

A systematic review conducted by Tournavitis et al. (2022) investigated the effectiveness of conservative therapeutic modalities for pain related to temporomandibular disorder (TMD). The search identified 28 randomized clinical trials (RCTs) published between 2001 and 2021 that met the inclusion criteria, focusing on patients over 18 years with TMD-related pain diagnosed using Research Diagnostic Criteria or Diagnostic Criteria for TMD. The primary outcome showed that occlusal splints, alone or combined with other therapies, significantly reduced short-term TMD pain compared to controls. Additionally, laser and photobiomodulation therapies had a statistically significant effect on alleviating TMD-related pain in the short term [19].

Low-level laser therapy (LLLT) has shown promising biomodulatory potential, particularly when applied to acupuncture points to address signs and symptoms related to the stomatognathic system. A systematic review analyzed clinical studies on the use of LLLT at acupoints in pediatric dentistry following the guidelines of the Cochrane Collaboration. A search across four databases up to June 2022 identified four studies using LLLT for photobiomodulation, with infrared wavelengths (716–980 nm) being the most common. Application times ranged from 14 seconds to 1 minute, with doses between 1 and 5 joules. LLLT demonstrated positive effects on various acupuncture points, benefiting pediatric dental patients by reducing preanesthetic pain, the gag reflex during procedures, and symptoms of sleep bruxism. Despite its potential, future research should focus on standardizing study designs and analytical methods to strengthen evidence in this field [20].

Intravascular irradiation of blood (ILIB) is a systemic modality of PBM that can be used as complementary therapy to other therapies. ILIB is considered a very promising method of systemic photobiomodulation. This method is painless and inexpensive and is capable of either stimulating or inhibiting cellular processes [21]. Light is used to stimulate the immune system and promote the tissue repair process. According to the literature, ILIB produces therapeutic effects, such as neurotransmitter regulation and synchronization [22], emitting energy that activates neuro-humoral regulation and synchronization as well as cellular modulation, with antioxidant, metabolic, immunological, antispasmodic, sedative, healing, analgesic, and anti-inflammatory properties. Additional effects include an increase in blood circulation, the stimulation of the limbic system and hypothalamus, a hormonal effect that contributes to regulating sleep and mood, and the normalization of endorphin and serotonin levels, generating wellbeing and improving quality of life [23, 24].

Therefore, the aim of the present study was to investigate the effectiveness of ILIB combined with orofacial myofunctional therapy for the treatment of sleep bruxism in a randomized controlled clinical trial involving children and adolescents between three and seventeen years of age.

2. MATERIAL AND METHODS

2.1 Study population

Forty-six children and adolescents between three and seventeen years of age were recruited from the Dental Clinic of Universidad Católica del Uruguay in the period from September 1st to December 20th, 2022. The participants were randomly allocated to two groups. G1 received active ILIB combined with an orofacial MFT exercise protocol and G2 received sham ILIB combined with the same orofacial MFT exercise protocol.

2.1.1 Inclusion criteria

• Children and adolescents between three and 17 years of age diagnosed with sleep bruxism and in treatment for other conditions at the dental clinic of the Universidad Católica del Uruguay;
• Male and female children and adolescents diagnosed with SB.

2.1.2 Exclusion criteria
• Individuals with dental caries;
• Use of medications, such as anti-inflammatory agents, muscle relaxants, corticosteroids, anticonvulsants, or antidepressants;
• Presence of chronic diseases that affect the muscles or motor coordination;
• Children with cerebral palsy;
• Failure to cooperate during the examination.

2.2 Sample size

The sample was calculated to detect a significant difference between PBM and MFT with 80% power and a significance level of 5%, considering the oxygen saturation index. Based on the study by Aarab et al. [25] to detect a difference in saturation index with an effect size of 0.53, the minimum number per group should be 23 participants.

2.3 Randomization

The participants were randomly distributed between the experimental groups using a random sequence generator (https://www.randomizer.org/tutorial/). Opaque envelopes were labeled with individual numbers. Each envelope contained a sheet of paper with information on the corresponding experimental group. The sequence generation and envelope preparation were carried out by a person not otherwise involved in the study.

2.4 Blinding
The participants did not know whether they belonged to the active or sham ILIB group, as the laser application was simulated. Unblinding was not permissible.

2.5 Interventions

Allocation of the participants to the different groups was performed using a randomization model from the site www.randomizer.com. The participants were allocated to two treatment groups: G1 (active ILIB and orofacial MFT) and G2 (sham ILIB and orofacial MFT).

Parents/guardians answered a questionnaire addressing bruxism [26] and completed the Pittsburgh Sleep Quality (PAQ) index [27]. Nocturnal oximetry was also performed at the home of each participant. Oral functions were assessed by a specialist in orofacial movements. Breathing pattern was investigated using the Glatzel mirror. The Payne method was used for the assessment of swallowing, which investigates tongue posture at rest and during functioning (swallowing). A functional assessment of chewing was performed by the specialist in orofacial movements, who had undergone training and calibration exercises.

The participants were unaware whether they belonged to G1(active ILIB) or G2 (sham ILIB), as the sham laser application was simulated. Unblinding was not permissible. ILIB was performed with red laser irradiation on the radial point with a wristband. Treatment was performed at a wavelength of 660 nm once a week for four weeks, with approximately 10 minutes per session. The G1 received active ILIB protocol. G2 received sham ILIB – simulation of the procedure with the laser switched off [28].

The specialist in orofacial movements performed myofunctional therapy [29,30] and the participants were instructed to continue the exercises for five minutes twice a day. The myofunctional orofacial therapy (MOT) exercise protocol applied in this study was designed to improve the orofacial functions of breathing, chewing, and swallowing, as well as to contribute to the management of bruxism in children and adolescents. The exercises implemented, their purpose, specific instructions for performing the exercises, duration, frequency, and necessary precautions are detailed below.

Lingual-palatal fixation

- Objective: To strengthen the lingual muscles and establish an adequate posture of the tongue at rest.
- Instructions:

1. Ask the patient to place the tip of the tongue against the hard palate just behind the upper incisors, avoiding touching the teeth.
2. Maintain this position while taking relaxed breaths through the nose.

- Duration: Maintain the position for 10 seconds.
- Frequency: Repeat 10 times per session, twice a day.
- Precautions: Make sure that the tongue does not make contact with the teeth to avoid undue pressure and ensure a relaxed posture during the exercise.

Lingual pressure against hard palate

- Objective: To increase tongue strength and improve neuromuscular control.
- Instructions:

1. Tell the patient to press the tip of the tongue against the hard palate, generating firm but comfortable pressure.
2. Maintain the pressure for the stipulated time while keeping the lips relaxed and the mouth half-open.

- Duration: Push 10 times and swallow.
- Frequency: Repeat 3 times, twice a day.
- Precautions: Make sure that the patient does not over-strain the muscles to avoid fatigue and discomfort.

Inflated cheeks with tongue on palate

- Objective: To improve muscle tone and coordination among tongue, lips, and cheeks.
- Instructions:

1. Ask the patient to inflate both cheeks with air while keeping the tongue in contact with the hard palate.
2. Maintain the position for the indicated time, preventing air from escaping through the lips while breathing through the nose.

- Duration: Maintain the position for 3 minutes.
- Frequency: Twice a day.
- Precautions: Make sure the patient does not overload the facial muscles and breathes properly through the nose during the exercise.

Alternated chewing in posterior region

- Objective: To promote functional and symmetrical chewing on both sides of the jaw.
- Instructions:

1. Ask the patient to chew a soft food (such as a piece of bread) alternating between the right and left side of the posterior dentition.
2. Perform the exercise slowly to ensure that mastication is complete and uniform.

- Duration: Chew for 15 seconds on each side.
- Frequency: Repeat twice a day.

• Precautions: Ensure that the food remains in the posterior sector of the dental arch to be crushed by the molars.

<u>General instructions for exercises</u>
1. Supervision: The exercises should be performed under the initial supervision of an orofacial motor specialist to ensure the proper technique.
2. Practice at home: Participants and their parents/caregivers were instructed to continue the exercises at home according to the guidelines provided.
3. Recording: Caregivers were advised to record the frequency and duration of the exercises performed daily to monitor adherence.

At the end of the fourth week after the ILIB and exercise sessions, nocturnal oximetry and the assessment of orofacial functions were performed again, along with the administration of the sleep quality and bruxism questionnaires [26,27]. Thus, each participant was submitted to two assessments – before and after the end of treatment.

2.6 Data analysis

The PSQ, bruxism questionnaire, % oxygen saturation (%O_2sat), swallowing, chewing, and respiration were determined before (T0) and after (T1) treatment with active or sham intravascular laser irradiation of the blood and orofacial therapy in a sample of 46 individuals divided into two groups: G1 (active ILIB) and G2 (sham ILIB). The variables were first submitted to descriptive analysis, followed by hypothesis tests to determine changes in the variables after each treatment, comparing the effects. The linear relationship between bruxism and %O_2 sat was then investigated in each group. All graphs, calculations, and hypothesis tests were performed using the R program, V 4.3.1.

3. RESULTS

Fifty-two participants were screened, 48 of whom were randomized and 46 were treated and followed up (Figure 1).

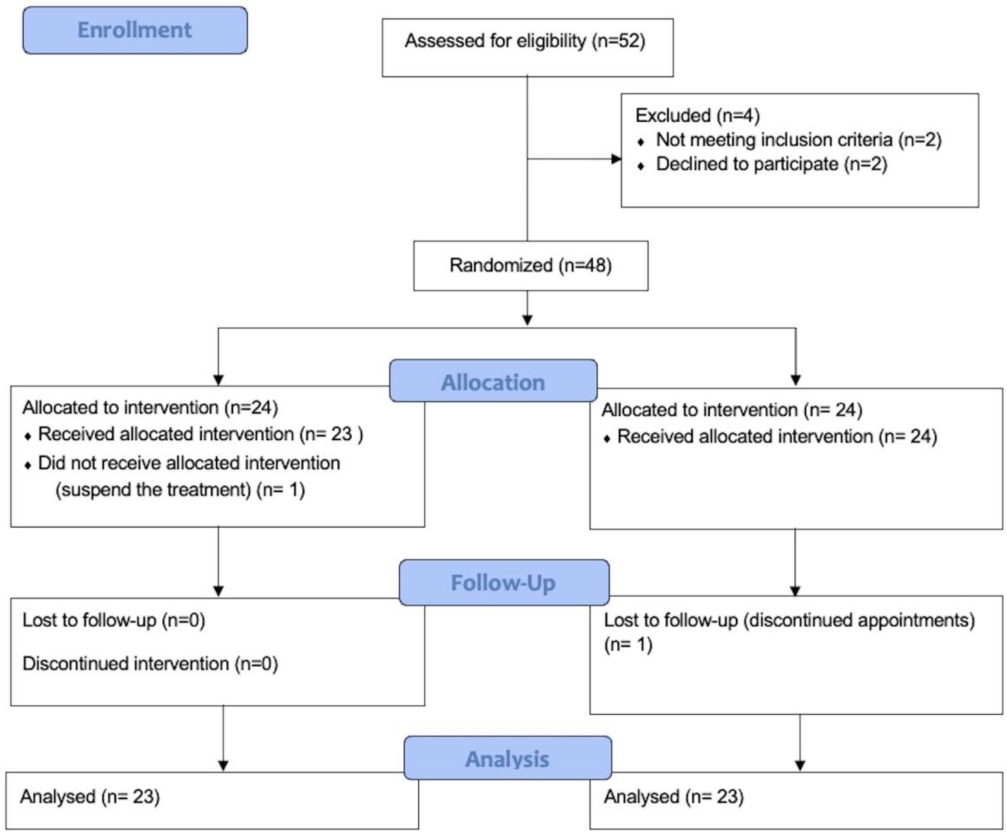

Figure 1. Flow diagram of study according to CONSORT 2010.

3.1 Swallowing, breathing, and chewing

Assessed by a speech therapist specialized in orofacial motor skills before and after the combined treatment for four weeks. The assessment was carried out with an estimation scale (1 = altered, 0 = normal) to estimate:

- Respiratory characterization of air intake, which explains the anatomical and topographic situation of the entry of air into the respiratory system (respiratory mode) to the thoracoabdominal movement zone that integrates inspiration and expiration. For this assessment, an observation was made with the aid of a Glatzel mirror to determine the state of the upper respiratory tract anatomically and its functional correlation.
- For swallowing, the Payne test was used, which addresses the posture of the tongue both at rest and during function (swallowing).

3.2 Functional assessment of chewing, breathing, and swallowing by orofacial motor specialist

After the assessment, improvements in the three variables were found in all patients after both treatments (from value 1 to value 0). Therefore, no significant differences between groups were found and the confidence interval had a single value, as can be seen in Table 1.

Table 1. Chewing / Breathing / Swallowing – Assessment

Variables	Groups	T 0		T 1	
		$\bar{x}$	CI	$\bar{x}$	CI
Chewing	**G1**	1	1-1	0	0-0
	G2	1	1-1	0	0-0
Breathing	**G1**	1	1-1	0	0-0
	G2	1	1-1	0	0-0
Swallowing	**G1**	1	1-1	0	0-0
	G2	1	1-1	0	0-0

Table 1 displays the data related to the variables (means and confidence intervals) before (T0) and after (T1) treatment in G1 (active ILIB) and G2 (control). The values indicate the proportion of participants with alteration (1) or normality (0) in the function assessed. The assessment was performed by a specialist in orofacial motor function using a binary clinical observation scale. Comparing the results of G1 and G2, no differences were found, as both treatments were equally effective at achieving improvements in all patients (p-value = 0), as can be seen in the Table 2.

Table 2. Comparing results between G1 and G2.

Variable	p-value G1	p-value G2
Chewing	0	0
Breathing	0	0
Swallowing	0	0

A p-value of "0" indicates the absence of statistically significant differences between the two groups, which reflects that both treatments were equally effective.

3.3 Pittsburgh Sleep Quality - PSQ

The Pittsburgh Sleep Quality questionnaire was administered to the parents/guardians before and after treatment. A significant improvement was found in G1 following treatment. Thus, the null hypothesis was rejected for the PSQ, as a significant reduction in the score was found following the application of active ILIB. In the intergroup analysis, the improvement in the PSQ score was greater in G1 compared to G2, as shown in Figure 2.

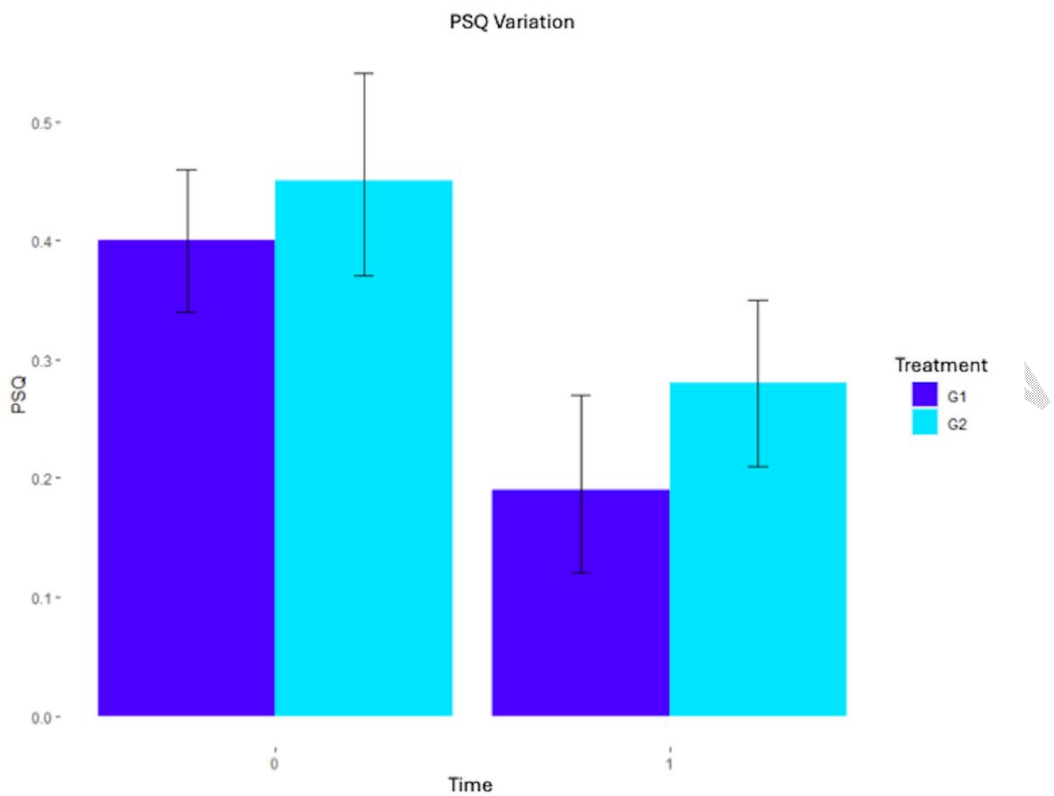

Figure 2. Change in PSQ score in G1 and G2.

3.4 Bruxism

The parents/guardians answered the questionnaire addressing bruxism before and after treatment. Table 3 displays the bruxism scores before and after treatment in G1.

Table 3. Bruxism score before and after treatment in G1

Variable	T0	T1	p-value
	$\bar{x}$	$\bar{x}$	
Bruxism	1.6	0.7	0.001

Based on the data displayed in Table 3, the null hypothesis was rejected for bruxism, as a significant reduction in the score was found following the application of active ILIB. In the intergroup analysis, the improvement in the bruxism score was significantly greater in G1 compared to G2, as shown in Figure 3.

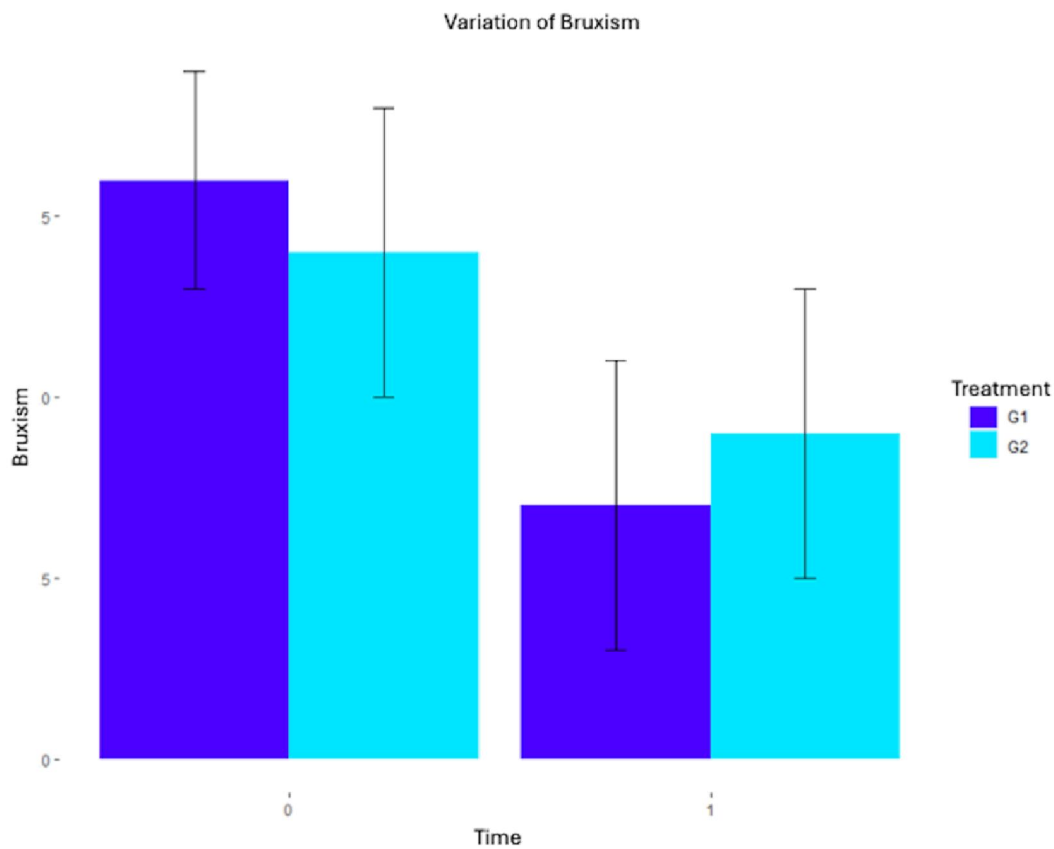

Figure 3. Change in bruxism score over time in G1 and G2.

3.5 Oxygen saturation

No significant difference in $\%O_2$sat was found after treatment in G1 ($p = 0.105$) (Table 4). In contrast, a significant improvement was found in G2 ($p < 0.05$), with oxygen saturation going from 96.2% before treatment to 96.9% after treatment.

Table 4. Mean oxygen saturation before and after treatment in G1

Variable	**T0**	**T1**	**p-value**
	$\bar{x}$	$\bar{x}$	
% O_2 saturation	96.6	96.9	0.105

3.6 Regression of bruxism and oxygen saturation

The linear relationship between bruxism and $\%O_2$ sat was weak or nil in both groups, as demonstrated by the low R^2 values and p-values higher than 0.05. A better linear relationship was found in G1 compared to G2, although the data indicate a weak relationship in both cases (Table 5).

Table 5. Linear regression parameters of bruxism vs. $\%O_2$ sat in G1 and G2

Treatment	**R^2**	**p-value**
G1	0.0815	0.1977
G2	< 0.0001	0.9741

4. DISCUSSION

Both treatments were equally effective at improving the variables related to orofacial functions (breathing, chewing, and swallowing), with no significant difference between G1 and G2. This demonstrates that orofacial MFT was effective in the treatment of SB, whereas ILIB was not decisive in the improvement in these orofacial functions in patients with SB.

Messina et al. (2017) investigated the effectiveness of myofunctional therapy at reducing chronic facial pain associated with bruxism. A total of 24 patients underwent myofunctional therapy for nine months. Pain intensity, episodes of bruxism per hour, and electromyographic activity of the temporal, masseter, sternocleidomastoid, and digastric muscles were assessed before and after treatment. Results demonstrated significant reductions in pain intensity, bruxism episodes, and muscle activity, including a decrease in tonic masseter activity and electrical activity of the temporal and digastric muscles during mandibular serration. These findings suggest that myofunctional therapy may be an effective intervention for mitigating chronic facial pain caused by bruxism [31].

The results of the present study with regards to the effects of orofacial MFT are compatible with data reported in the literature, demonstrating that treatment with these exercises has a positive impact on orofacial functions affected by bruxism [23]. The aim of these myofunctional exercises is to strengthen the dilating muscles of the pharynx to reduce collapsibility, thus improving the endurance, neuromuscular coordination, stability, and tone of this muscle group [24]. Orofacial MFT can be administered by a speech therapist to correct orofacial muscle imbalance and abnormal swallowing patterns derived from bite and speech complications [23]. Thus, speech therapists constitute an important component of the multidisciplinary team, as such healthcare providers are responsible for structural and functional aspects of the orofacial and neck region with the aim of achieving a balance in the stomatognathic system [24].

A meta-analysis was conducted to synthesize findings from various studies on the treatment of bruxism in children. The studies reviewed assessed the effects of novel therapies for bruxism compared to either occlusal splints or placebo treatments. Among the interventions, photobiomodulation emerged as the most effective, followed by hydroxyzine. Evidence suggests that photobiomodulation (PBM) inhibits the movement of delicate nerves along their axons, decreases mitochondrial potential, and consequently reduces the availability of adenosine triphosphate (ATP) necessary for nerve activity. The primary objective of applying photobiomodulation to the muscles of the head and neck is to alleviate pain associated with temporomandibular disorders [32].

Although studies show that photobiomodulation is an effective treatment for bruxism, our study used intravascular photobiomodulation (ILIB), which was not decisive in the improvement in orofacial functions. This may be related to the fact that this therapeutic modality is more effective in other systems of the body, such as the lymphatic system [25]. In contrast, significant improvements were found in sleep quality and bruxism, with improvements in the PSQ found in both groups and a greater improvement in bruxism found in G1, which indicates that ILIB favored the reduction in bruxism in the participants. A significant improvement in the percentage of O2 saturation was only found in G2 ($p < 0.05$). Therefore, although encouraging, the results are not conclusive. Future studies should combine both therapies into a single group, which may provide promising results.

Therefore, the quest for possible therapeutic options for SB continues, especially in children and adolescents, as studies indicate that psychopathological, neuropathological, and neurochemical aspects may be present in SB due to the modulation of neurotransmitters [3,28,33]. Moreover, the multifactorial etiology, which further complicates the establishment of an ideal therapy for affected individuals, leads us to believe that treatment for SB should have a multidisciplinary approach, with the involvement of dentists, speech therapists, and psychologists [34].

CONCLUSION

Intravascular laser irradiation of the blood favored a reduction in bruxism and PSQ scores but was not decisive in the improvement of oxygen saturation or orofacial functions, such as breathing, swallowing, and chewing. Thus, intravascular laser irradiation of the blood showed promise in reducing bruxism and PSQ scores. However, its impact on improving oxygen saturation and orofacial functions, such as breathing, swallowing, and chewing, was not conclusive. These findings suggest that, while Intravascular laser irradiation of the blood may offer significant benefits in the management of bruxism, additional approaches may be necessary to address other aspects of orofacial function. Further research is warranted to gain a better understanding of the therapeutic potential of intravascular laser irradiation and its effects on orofacial functions in patients with bruxism.

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COMPETING INTERESTS

The authors declare no competing interests.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

CONSENT AND ETHICAL APPROVAL

The study received approval from the Human Research Ethics Committee of Universidad Católica del Uruguay (process number: 220211) and was registered with Clinical Trials (https://clinicaltrials.gov/) under number NCT05301452. The guardians of the children agreed to participate by signing a statement of informed consent; two copies of which were signed: one for the guardian and one for the researchers. They were also informed that they could withdraw from the study at any time for any reason if they so wished. The researchers also had the ability to remove participants from the study, if deemed necessary.
A randomized, controlled, parallel-group, single-blind, clinical trial was conducted involving children and adolescents with a diagnosis of sleep bruxism.

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Disclaimer (Artificial intelligence)

The authors hereby declare that NO generative AI technologies, such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators, were used during the writing or editing of this manuscript.

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