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Low-level laser therapy, at 830 nm, for pain reduction in experimental model of rats with sciatica

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ABSTRACT
Chronic pain, resulting from nerve compression, is a common clinical presentation. One means of conservative treatment is low-level laser therapy, although controversial. The aim of this study was to evaluate the effects of two doses of low-level laser, at 830 nm, on pain reduction in animals subjected to sciatica. Eighteen rats were used, divided into three groups: GS (n=6), sciatica and simulated treatment; G4J (n=6), sciatica and treatment with 4 J/cm^2; and G8J (n=6), sciatica and irradiation with 8 J/cm^2. The right sciatic nerve was exposed and compressed using catgut thread. Five days of treatment were started on the third postoperative day. Pain was assessed by means of the paw elevation time during gait: before sciatica, before and after the first and second therapies, and the end of the fifth therapy. Low-level laser was effective in reducing the painful condition.
Key words: pain measurement, sciatica, low level laser therapy.

Laser de baixa potência, 830 nm, na redução da dor em ratos submetidos à modelo experimental de ciatalgia

RESUMO
A dor crônica, resultante de compressão nervosa, é uma apresentação clínica frequente. Um dos meios de tratamento conservador, é o laser de baixa potência, apesar de controvérsias. O objetivo do estudo foi avaliar os efeitos de duas doses de laser de baixa potência, 830 nm, na redução da dor em animais submetidos à ciatalgia. Foram utilizados 18 ratos, divididos em 3 grupos: GS (n=6) ciatalgia e simulado o tratamento; G4J (n=6) ciatalgia e tratado com 4 J/cm^2, G8J (n=6) ciatalgia e irradiado com 8 J/cm^2. O nervo isquiático direito foi exposto e realizada a compressão com fio *catgut*. No 3° dia pós-operatório, iniciou-se o tratamento, durante 5 dias. Verificou-se a dor, por meio do tempo de elevação da pata, na marcha: anterior à ciatalgia, pré e pós 1ª e 2ª terapias, e ao final da 5ª terapia. O laser de baixa potência foi eficaz na redução do quadro álgico.
Palavras-chave: medição da dor, ciática, terapia a laser de baixa intensidade.

Chronic pain in the lower limbs is a common clinical presentation and may be due to various causes, such as chronic compartment syndrome, tendinitis, shin splints, stress fractures, fascial lesions, myotendinous junction disruption, popliteal artery compression syndrome, vein thrombosis induced by physical exertion and nerve compression. The typical presentation of nerve compression is paresthesia and pain started by the activity, which is exacerbated with sustained exercise[1,2].

Neuropathies of the sciatic nerve can occur at any level from the abdomen to the knee. In the gluteal region, local trauma, pelvic fractures, hip fractures and dislocations or space-occupying lesions may compress the nerve[3]. Sciatica is a form of radicular pain, and is described as a disease of the peripheral nervous system. It is a common condition and the

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main cause of absences from work, with great financial cost to health services[4].

Patients with compressive neuropathy complain of a burning sensation and paresthesia along the nerve distribution that is involved. Weakness and atrophy of muscles innervated by compressed nerve may also occur[2]. Evidence suggests that inflammation, abnormal immune factors and mechanical deformation of the nerve are needed to produce pain, and the most common site of problem genesis is the intervertebral disc. However, malignant tumors, abscesses, vascular compression, osteophytes and piriformis syndrome are also possible sources of sciatica[4].

Piriformis syndrome has been described as a form of nerve compression causing pain along the hamstrings and across the buttocks. In sports medicine, in which chronic hamstring pain is a common problem, this syndrome is a possible explanatory cause for these symptoms. The pain is exacerbated by flexion at the hip combined with active external rotation or passive internal rotation, and spasms are usually palpable on the obturator internus and piriformis[3].

Conservative treatment, consisting of modifying the pain-precipitating activity, biomechanical correction with physiotherapy or the use of antidepressants, analgesics and/or steroids, are common forms of therapy[1,2]. However, treatment with drugs has undesirable effects and, for this reason, physical methods have been advancing because of the absence of side effects[5]. Among the resources available for treating peripheral nerve injuries within the field of physiotherapy, low-level laser therapy stands out because of its possible anti-inflammatory[6], analgesic[7], repair and nerve function[8-11] effects. However, there is controversy about the effectiveness of laser therapy for producing analgesia in cases of nerve compression[12], which may be related to the fact that low-level laser therapy is wavelength-specific[6]. Thus, the aim of the present study was to evaluate the effects of two doses of low-level laser (4 and 8 J/cm^2) at 830 nm wavelength, on pain reduction in animals subjected to an experimental model of sciatica.

METHOD

Animals

Eighteen Wistar rats (Rattus norvegicus), weighing 376.40±31.08 g and aged 14±2 weeks were housed in polypropylene cages and subjected to light/dark cycles of 12 hours, receiving water and food ad libitum throughout the experimental period.

The animals were randomly divided into three groups:

- GS (n=6): Subjected to sciatica in the right hind limb, with placebo treatment (sham);
- G4J (n=6): Subjected to sciatica and treated with low-level laser therapy, 830 nm, with a dose of 4 J/cm^2;
- G8J (n=6): Subjected to sciatica and treated with a dose of 8 J/cm^2.

The project was carried out in accordance with the international ethics standards for animal experimentation[13], as approved by the Animal Ethics and Practices Sections at UNIOESTE.

Experimental sciatica

The animals were anesthetized with xylazine (12 mg/kg) and ketamine (95 mg/kg) intraperitoneally and were then shaved at the surgery site. An incision was made parallel to the biceps femoris fibers of the animal's right thigh, to expose the sciatic nerve. In accordance with the original model described by Bennett and Xie[14], we compressed the nerve at four different locations, at a spacing of approximately 1 mm from each other, using chromic catgut 4.0 thread to reproduce chronic pain. The incision was then sutured in layers.

Pain measurement

For pain evaluation, the rat knee joint incapacitation test originally described by Tonussi and Ferreira[15] was used. This test aims to evaluate pain during the animal's gait, i.e. its functional form. The test consists of using a metal cylinder of approximately 30 cm in diameter that is in motion at 3 rpm, and a computer program connected to a metal boot adapted to the animal's paw. The animal walks for one minute on the cylinder and its paw elevation time (PET) is assessed.

The experiment began with training the animals on the cylinder. On the next day, PET values relating to normal gait were recorded. Surgery for sciatic nerve compression was then performed, and the animal was revaluated on the third postoperative day (before and after the first treatment), fourth postoperative day (before and after the second treatment) and seventh postoperative day (after the fifth treatment). Normally, animals without abnormalities keep their paws in the air for about 10 seconds during their gait, while animals with pain have longer periods of PET[16].

Treatment protocol

On the third postoperative day, treatment using low-level laser with a 830 nm wavelength and 30 mW power (IBRAMED®) was started. The laser source had previously been tested to certify the dose given to each group. For laser therapy application, specifically over the surgical incision, the animals were immobilized in a retainer made of PVC thermoplastic material, as originally described by Lirani[17]. This procedure was used for five daily treatments, with an interval of 24 hours between applications. The animals in the GS group followed the steps described above, but the laser equipment was not switched on. The

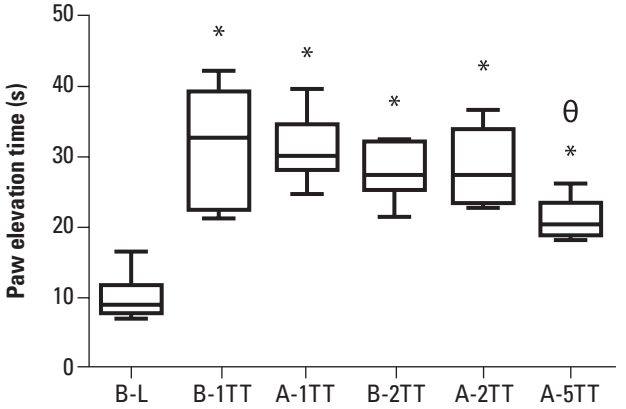

Fig 1. Graphic demonstration of the paw elevation time (PET) values for the GSsham group, at different evaluation times (B-L: before lesion; B-1TT: before first treatment; A-1TT: after first treatment; B-2TT: before second treatment; A-2TT: after second treatment; A-5TT: after fifth treatment). *Statistically significant difference in relation to the pre-surgery value. θ Statistically significant difference in relation to the post-surgery values.

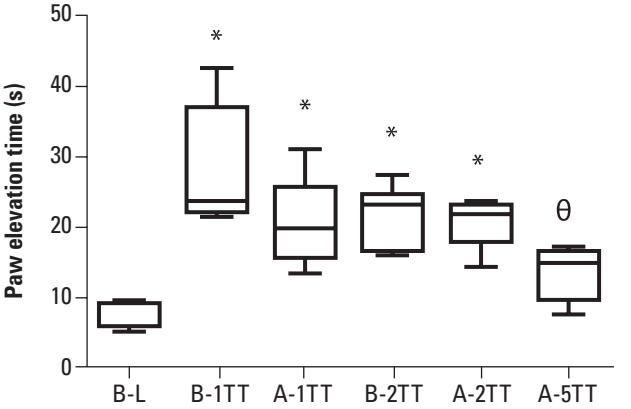

Fig 2. Graphic demonstration of the paw elevation time (PET) values for the G4J group, at different evaluation times (B-L: before lesion; B-1TT: before first treatment; A-1TT: after first treatment; B-2TT: before second treatment; A-2TT: after second treatment; A-5TT: after fifth treatment). *Statistically significant difference in relation to the pre-surgery value. θ Statistically significant difference in relation to the post-surgery values.

sciatic nerve of the left pelvic limb was not subjected to compression and processing. On the day after the last treatment, the animals were killed by decapitation.

Statistical analysis

The data obtained were analyzed statistically by means of one-way analysis of variance (ANOVA) with repeated measurements for comparisons within groups, and one-way ANOVA for comparisons between groups. In both cases, the Bonferroni post-hoc test was also used. In all cases, the significance level accepted was 5%.

RESULTS

The results were analyzed by making comparisons between pre-and post-injury times.

For GS, the PET showed a significant increase at the measurement times following the injury, with no significant decrease. However, comparing the measurement after the injury with the measurement on the fifth day of simulation, there was a significant reduction in PET values (Fig 1).

For G4J (Fig 2) and G8J (Fig 3), in the same way as for GS, there was a significant increase in PET after the injury. However, the PET value on the fifth day of treatment was not significantly different from the pre-surgery value. For G8J, there was no significant difference, when comparing the PET values on the fifth day of therapy with the time prior to the first treatment.

Comparison between the groups showed that there were significant differences between GS and G4J at the following measurement times: after the first treatment, before the second treatment and after the fifth treatment.

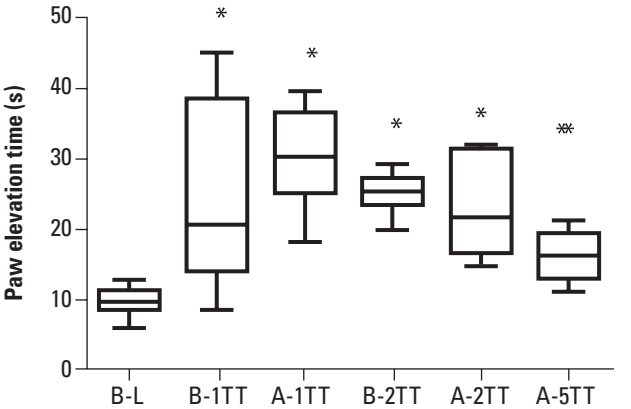

Fig 3. Graphic demonstration of the paw elevation time (PET) values for the G8J group, at different evaluation times (B-L: before lesion; B-1TT: before first treatment; A-1TT: after first treatment; B-2TT: before second treatment; A-2TT: after second treatment; A-5TT: after fifth treatment). *Statistically significant difference in relation to the pre-surgery values.

DISCUSSION

The sciatic nerve is the largest in the human body. It can be injured under several of circumstances, such as crushing, transsection, stretching and freezing. Experimental models for sciatic nerve compression in rats have been used to assess chronic pain, due to the resemblance between the sciatic nerves of rats and humans[18]. In this study, we used a model for sciatic compression in rats that mimics the symptoms of sciatica[14], in order to evaluate pain evolution following low-level laser therapy at a wavelength of 830 nm and with doses of 4 and 8 J/cm^2, by means of gait analysis in a model produced by Tonussi and Ferreira[15].

The assessment showed that pain was present on the third postoperative day and extended at least until the seventh postoperative day. It was observed for the placebo group and similarly for the treated groups, with a significant increase in PET at the time prior to starting the treatment, and the difference persisted until the fifth day of treatment simulation. This is in agreement with the report from Bennett[19], indicating that there is evidence of pain in animals starting from the second postoperative day. The use of the equipment turned off, thus simulating the laser application, is important because the presence of a placebo group is essential for valuing the desired equipment[20].

According to Cunha et al.[21], animals subjected to this type of nerve compression present PET of more than 10s, which was also observed in this study. These authors evaluated laser equipment with a wavelength of 670 nm and observed that the dose of 4 J/cm^2 produced a return to the initial PET values after 10 days of treatment, which did not occur when using 2 J/cm^2. Hence, the wavelength may be a key factor for the therapeutic effects. In our study, we chose to use 830 nm, i.e. within the near infrared spectrum, with doses of 4 and 8 J/cm^2, and found that for both doses, there were pain reduction effects by the end of the series of five daily applications of therapy, since there was no significant difference in comparison with the preoperative values.

According Hagiwara et al.[22], the pain reduction caused by the laser of 830 nm may come from effects relating to the release of endogenous opioids. However, in our study, in the assessments made before and after the first and second days of treatment, there were no significant differences for any of the groups. For G4J alone, there was a decrease in comparison with the other two groups at the first measurement time after therapy, and the evaluation remained different after the second and fifth treatments of the control group. It may be possible to infer that there were benefits from this therapeutic dose, compared with the other groups, but the sum of the therapy is that it produces the best therapeutic effect and not isolated therapies.

Analgesia can also be credited to decreases in nociceptor sensitization within the inflammatory process[5], or even to reductions in inflammatory mediators such as PGE_2[23]. Pain due to inflammation is characteristic of sciatica[4], and there has been speculation that low-level laser therapy can be used in cases of patients with sciatica. According to Ekim et al.[24], there are positive effects from infrared laser (780 nm), on the pain in cases of nerve compression (carpal tunnel syndrome), beyond functional improvement.

In this study, we used two doses of low-level laser therapy, but we suggest that other doses could be tested in future research. It should also be noted, as a limitation of the present study, that it did not correlate with the histological findings, which could also be the research focus in future studies.

Based on these results, we concluded that low-level laser therapy with a wavelength of 830 nm, at the doses used, produced a pain reduction in animals subjected to an experimental model for sciatica.

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