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Low-Level Laser Treatment Can Reduce Edema in Second Degree Ankle Sprains

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ABSTRACT

***Objective:* Low-level laser therapy (LLLT) has been used for the last few years to treat sports injuries. The purpose of this study was to compare three therapeutic protocols in treating edema in second degree ankle sprains that did not require immobilization with a splint, under placebo-controlled conditions. *Materials and Methods:* Forty-seven soccer players with second degree ankle sprains, selected at random, were divided into the following groups: The first group (n = 16) was treated with the conventional initial treatment (RICE, rest, ice, compression, elevation), the second group (n = 16) was treated with the RICE method plus placebo laser, and the third group (n = 15) was treated with the RICE method plus an 820-nm GaA1As diode laser with a radiant power output of 40 mW at 16 Hz. Before the treatment, and 24, 48, and 72 h later, the volume of the edema was measured. *Results:* A three by three repeated measures ANOVA with a follow up post hoc test revealed that the group treated with the RICE and an 820-nm GaA1As diode laser presented a statistically significant reduction in the volume of the edema after 24 h (40.3 ± 2.4 mL, $p < 0.01$), 48 h (56.4 ± 3.1 mL, $p < 0.002$), and 72 h (65.1 ± 4.4 mL, $p < 0.001$). *Conclusions:* LLLT combined with RICE can reduce edema in second-degree ankle sprains.**

INTRODUCTION

SPRAINS of the lateral ligaments of the ankle joint are frequent among athletes, but also the general population.[1] They account for 45% of injuries occurring in basketball,[2] 29% of injuries of the lower extremities occurring in soccer,[3] and 20–30% of all injuries occurring in this sport.[4,5] An injury of the soft tissue is followed by local inflammation, which is characterized by a sequence of reactions. The formation of edema is part of that sequence.[6] Although edema is considered a normal response to injury, it frequently causes pain and loss of the function of the limb.[7,8] A review of the relevant literature revealed that various therapeutic protocols are used to contain the edema. The conventional initial treatment (RICE, rest, ice, compression, elevation) is the most common treatment for many soft tissue injuries.[9,10] In addition, numerous studies support the view that both elastic wrap (compression)[11] and elevation,[12] have a beneficial effect on edema formation following ankle sprains not requiring immobilization. Other researchers have used electron-acupuncture (stimulation of the acupuncture points with transcutaneous electrical nerve stimulation), but also using low frequency interrupted galvanic current,[13–16] with positive results. We are not aware of any study comparing the traditional RICE method with low-frequency laser treatment to contain edema in second-degree ankle sprains.

The purpose of this study was to compare three therapeutic protocols in treating edema in second-degree ankle sprains that did not require immobilization with a splint: (1) application of the conventional treatment (RICE method), (2) application of RICE plus placebo laser, and (3) application of RICE plus an 820-nm GaA1As diode laser with a radiant power output of 40 mW at 16 Hz. Since it is a known fact, that one of the three biological effects of low-level laser treatment is anti-inflammatory action,[17] we hypothesized that the edema would show a substantial reduction following treatment with RICE and an 820-nm GaA1As diode laser after 24, 48, and 72 h, a change that was not expected in the other groups.

MATERIALS AND METHODS

Selection of subjects and randomization

Soccer players that were presented with lateral ankle sprains between July 10, 1992 and May 20, 1998 to the Sports Medicine Lab, University of Athens, who were between 18–26 years

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old and whose injury had occurred earlier than 8 h, were selected. Eligible soccer players were given a detailed prescription of the purpose and methodology of the study and the chance to receive a placebo therapy. Moreover, the soccer players were informed about their right to withdraw from the study any time. After receiving this information in writing, the soccer players were given a signed informed consent.

After the consent, 47 soccer players were randomly allocated to one of three groups. The first group ($n = 16$), the therapeutic protocol of which provided only for the conventional initial treatment (RICE), the second group ($n = 16$) whose therapeutic protocol provided for the RICE method plus placebo laser, and the third group ($n = 15$) whose therapeutic protocol provided for the RICE method plus an 820-nm GaA1As diode laser, with a radiant power output of 40 mW at 16 Hz. Soccer players, physiotherapists, outcome assessors and statistician, were blinded to the treatment given. The Medical Ethics Committee of University of Athens and the University Hospital of Apostolos Pavlos approved the study.

Experimental process

The treatment of all subjects began 2 h after the initial diagnosis of injury. The low-power galium-aluminium-arsenide laser (Biotherapy 2000, manufactured by Omega Universal Technologies) was used. This laser operating with a single laser diode, was used for 5 min. Table 1 details the treatment parameters. Before laser treatment was applied, the area was cleaned with alcohol. Ten points around the lateral side of the ankle were irradiated.[18] The first treatment took place in the morning (10:00 a.m.), and the second treatment in the afternoon of the same day (6:00 p.m.). All three groups followed the same treatment schedule: two treatments per day for three days. The laser set produced a sound and a red display to all patients. For protection from the laser beam, all subjects wore glasses. Cold pressure pads (TRU 1042, PI Medical Comp., USA) were applied on all subjects, three times a day for 20 min per application. During the application of the cold pressure pad, the injured extremity was elevated, while throughout the rest of the day it was in an elastic wrap (PHN 7250, Mueller Sports Med., Inc., USA), in accordance with Knight.[19] The athletes were also advised not to put weight on the lower extremity during the treatment period and to use crutches for their daily activities.

TABLE 1. TREATMENT PARAMETERS

Active medium	GaA1As
Mode	Continuous wave
Wavelength	820 nm
Frequency	16 Hz
Angle of divergence	10°
Output	40 mW
Area of irradiation	0.16 cm^2
Energy per point	1.2 Joule
Energy density	7.5 J/cm^2
Number of irradiation points	10 in latelar malleous
Total irradiation time per point	30s
Interval time	5s

Measurements

The edema was measured using the volume-measuring method that measures water displaced when the limb was placed in a volumeter, which is made of Plexiglas and has an opening on top for the displaced water to overflow. Many researchers have used this method to measure the edema of the upper extremities,[20] as well as the lower extremities.[21] The reliability of this method has been pointed out by several researchers.[21,22] The procedure was as follows: The receptacle was filled with water until it stopped overflowing from the rim of the opening. The athlete would sit on a chair at a distance of 25 cm from the volumeter, and place the injured lower extremity in the volumeter very slowly—so as not to spill additional water during the submersion of the limb—until the heel touched the bottom and the sole was in a neutral position. The displaced water was collected and measured. Calculations were in milliliters. Water volumes recorded in the measurements following treatment, were subtracted from the first measurement. The difference represented the change in volume of the foot edema and the possible diminution of it.

To evaluate the reliability of this method the researcher measured the volume of a metal box for 10 successive trials and another physiotherapist recorded the measurements. There is no greater than a 2-mm variation between any measurements.

RESULTS

Data were stored in a personal computer and analyzed with SPSS statistical software. A three-by-three repeated ANOVA measures with a follow-up post hoc test, were used to identify significant differences of edema volume within and between groups during the 24, 48, and 72 h. The level of significant differences was set at $p < 0.05$.[23]

In all three groups after treatment, a reduction in measured edema volume was observed. It was determined that the largest change in volume occurred in the laser group, where on average, the volume decreased by 40.3 ± 2.4 mL after 24 h, by 56.4 ± 3.1 mL after 48 h, and by 65.1 ± 4.4 mL after 72 h (Table 2). The ANOVA within and between groups and a tukey post hoc analysis revealed that only significant differences were in group that received laser therapy: (1) after 24 h ($F = 4.97$, $p < 0.01$), (2) after 48 h ($F = 7.45$, $p < 0.002$), and (3) after 72 h ($F = 10.37$, $p < 0.001$).

DISCUSSION

In a second-degree ankle sprain, there is a definitive injury to the collagen fibres of the posterior talofibular ligament, but the ankle does not totally lose its stability. The symptoms are pain, sensitivity, limitation of joint movement, and bleeding. The athlete tends to keep the leg in a supine position, and edema develops in a very short time. The basic purpose of the therapy,

TABLE 2. TREATMENTS EFFECT ON ANKLE VOLUME

Treatment	Volume measurement (ml)		Change (ml), measurement
	Pretreatment	After 24 h	
RICE ($n = 16$)			
Mean	1517.6	1486.5	31.1
Standard error	40.8	38.5	1.9
Placebo ($n = 16$)			
Mean	1522.3	1490.2	32.1
Standard error	39.2	39.1	2.2
Laser ($n = 15$)			
Mean	1534.7	1494.4	40.3*
Standard error	50.1	40.8	2.4
	Pretreatment	After 48 h	
RICE ($n = 16$)			
Mean	1517.6	1479.4	38.2
Standard error	40.8	38.5	2.1
Placebo ($n = 16$)			
Mean	1522.3	1481.2	41.1
Standard error	39.2	38.7	2.3
Laser ($n = 15$)			
Mean	1534.7	1478.3	56.4**
Standard error	50.1	50.2	3.1
	Pretreatment	After 72 h	
RICE ($n = 16$)			
Mean	1517.6	1472.5	45.1
Standard error	40.8	36.1	2.2
Placebo ($n = 16$)			
Mean	1522.3	1474.9	47.4
Standard error	39.2	37.3	2.3
Laser ($n = 15$)			
Mean	1534.7	1469.6	65.1***
Standard error	50.1	48.4	4.4

Means and standard errors of pretreatment, 24, 48, and 72 h ankle volume measurements and volume changes.
*$p < 0.01$, **$p < 0.002$, ***$p < 0.001$.
RICE, rest, ice, compression, elevation.

at the acute stage, is to decrease the edema, since this causes severe pain. The basic mechanism causing edema, is the increased permeability of the capillary veins to plasma proteins.[25] As the plasma proteins shift in to the space between the tissues, the liquid must come out of the vascular bed, since this imbalance of proteins along the vascular wall will result in the formation of an edema.[26] The catalytic effects of laser beams are attributed chiefly to the electromagnetic energy absorbed by the tissue, leading to an increase in cell activity. These effects may either reinforce or suspend the biochemical and physiological activities of the cells.[27] The degree to which this effect will be positive, depends on the wavelength and power dose of the laser beams. Cells communicate among themselves via electromagnetic energy, which affects their anabolic and catabolic activities.[28] In the case of sprains, this communication among the cells is disrupted, and it is believed that restoration of the balance is achieved through laser beams.[29] Also the unique reaction of cells to laser photon beams is explained by the photochemical theory. According to this theory, radiation is absorbed by photoreceptors, which are possibly enzymes activated by laser photon beams and are considered responsible for the biological effects. It is believed that the action of the laser treatment will reduce the formation of edema, through suspending the outflow of the vascular wall's proteins.[17,25]

The results of the present study showed that an 820-nm GaA1As diode laser with a radiant power output of 40 mW at 16 Hz continuous wave combined with the RICE method contributed to the statistically significant decrease of edema, as compared to placebo laser combined with the RICE method, or to the RICE method alone, which is the traditional "first-aid" technique.

Axelson and Bjerno[30] studied the effect of low-level laser beams on second-degree ankle sprains, in 40 patients. Based on the results of that study, no significant differences were noted in the reduction of pain, in the edema or the discoloration of the skin in the group that took analgesic medication and the group that received laser treatment. But those results are contrary to the present study, in which significant differences were observed in the edema. The laser used by Axelson and Bjerno[30] was a GaAs 904 nm, whereas in this study a continuous emission Laser GaA1As 820 nm was used. Furthermore, there were greater differences concerning frequency and intensity of the dose given. Finally, only low-level laser energy was used, not in combination with traditional RICE method, that would make it difficult to compare the studies. Beckerman et al.,[31] after analyzing 36 papers, reached the conclusion that there were some indications that laser reduces pain and possibly edema, too. Conversely, Gam et al.,[32] analyzing 23 papers, did not confirm that laser reduces pain because they believe despite its widespread application, it is still too early for it to be accepted as a therapeutic method in treating various musculoskeletal problems.

The methodology used in the present study guaranteed its validity and reliability, since the measurement of the edema was performed with the acceptable volume measuring method for edema[21] and the results are considered satisfactory in comparison with the few studies that were found after a relevant search. But despite the improvement observed in the group that received laser treatment, more such investigative efforts are required with a larger number of subjects, and as well, comparison with traditional therapeutic protocols, such as ultrasound, electrotherapy currents, and transcutaneous electrical nerve stimulation (TENS), should be done.

CONCLUSION

Further studies are needed in order to provide detailed information on the effectiveness of various therapeutic laser modalities in the treatment of the second degree ankle sprains, not only in the acute phase, but as a part of a total rehabilitation program, including exercises.

Even though it is confirmed with the present study that edema can be decreased after this laser study design in combination of RICE, it is unwise for someone to consider laser as a panacea, since all studies are simply indicative. Further study is required so as to establish the correct laser parameters, mainly the wavelengths used in this treatment of soft tissue injuries.

The present study showed that after a second-degree ankle sprain, treatment with the traditional RICE modality combined with an 820-nm GaA1As diode laser with a radiant power output of 40 mW at 16 Hz continuous wave, produces better results than the RICE plus placebo laser GaA1As as well as the RICE-only protocol.

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