Effect of Low Intensity Laser Therapy on Sympathetic Activity in Healthy Subjects

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ABSTRACT

Low intensity laser therapy (LILT) is a popular modality in the field of physical therapy. The effect of LILT on sympathetic nervous system (SNS) has received little attention. This study was conducted to investigate the effect of low intensity laser therapy on sympathetic activity in healthy subjects. Totals of forty healthy males with age ranged from 24 to 30 years and mean age (27 ± 1.7) years participated in the study. The subjects were randomly divided into two equal groups: Laser group, and placebo group. Subjects in laser group received helium neon laser with wavelength (632.8 nm), continuos mode, energy density 1.7J/cm^2, and for duration of 17 minutes. Subject in placebo group received sham laser. Measurement of sympathetic skin response (SSR) amplitude were obtained from subjects in both groups at pre laser/sham irradiation and at post laser/sham irradiation within intervals of immediately, 5 minutes, and 15 minutes. Analysis of the data using repeated measure ANOVA revealed that helium neon laser produced significant reduction of SSR amplitude where (P<0.0001). While in the placebo group there was non-significant change of SSR amplitude (P> 0.5). The results of Bonferroni post hoc pair-wise comparison for laser group revealed that the reduction of SSR remained statistically significant (P<0.001) through 15 minutes post irradiation. The percentages of reduction of post irradiation (immediately, 5 and 15 minutes) values of SSR as compared to pre irradiation values were (53.7 %, 48.4 %, and 27.3 %). In conclusion, low intensity laser decreases sympathetic activity in healthy subjects and this reduction continued to 15 minutes post laser irradiation. In addition, the current study suggests possible involvement of sympathetic nervous system in laser mediated analgesia. Further research is needed to assess sympathetic reaction to different forms of laser, with different parameters to reach to the optimal effect of laser on SNS.

Key Words:. *Low intensity laser, sympathetic nervous system.*

INTRODUCTION

One of the important developments within the field of electrotherapy during the last decade has been the introduction of low intensity lasers. During recent years low level laser has become a popular modality among physiotherapists[25]. There are two cardinal uses of low intensity laser therapy (LILT), tissues healing and pain reduction[14]. Numerous clinical studies have shown LILT to be effective as analgesics in many conditions including arthritic and rheumatic pain[7,17],

musculoskeletal[3,18] and myofascial pain[19]. Laser also demonstrated positive results in alleviating neuropathic and neurogenic pain as neuralgia and radicular pain[16,27].

Although many studied have been conducted to verify the mechanisms of action underlying laser mediated analgesia, it remains unclear[25,31]. The proposed mechanisms explaining analgesic effect of laser may include its ability to increase pain thresholds and affecting electrically evoked potentials in terms of both conduction velocity and amplitude[9,22,23]. Also the analgesic effect of laser has been attributed to the alteration of the level of prostaglandins and histamine[31]. Another proposed mechanism is the neuropharmalogical effect of laser on serotonin and acetylecholine, which although not yet established, could propose central effect[3]. Therefore identification of underlying mechanisms of action was proposed to represent an important field for investigation especially in light of the skepticism surrounding this area[31].

One important area that has not received adequate investigations is the effect of low intensity laser therapy on sympathetic activity and its possible role in laser mediated analgesia.

Within the last 10 years, researches into the role of the sympathetic nervous system and pain have increased. It was reported that many pain-conducting nerve fibers enter the sympathetic ganglia, which may influence the sympathetic activity[10,21]. The interrelationship that exists between pain fiber activity and sympathetic activity has been established. Researches have demonstrated dynamic relationship in which painful sensation can led to increase sympathetic activity[32]. In other hand excessive sympathetic tone can lead to pain as in sympathetically maintained painful conditions for example Raynaud's disease, reflex sympathetic dystrophy and causalgia[4,5].

Despite this relationship between pain and sympathetic activity, the effect of low intensity laser therapy on sympathetic nervous system have not yet been established. No attempt to measure direct effect of LILT on sympathetic activity has been made. Some clinically based researches have been conducted to investigate the effect of LILT on some pain syndromes accompanied by increase sympathetic activity, and the results were encouraging. But these studies focused on the functional outcome without direct measurement of changes of sympathetic activity and its possible involvement in pain alleviation[1,10,20,27].

In the light of the previously presented literature, more studies would appear to be warranted to identify the precise effect of LILT on sympathetic activity and the relevance of that to the laser mediated analgesia.

Sympathetic skin response (SSR) is a simple objective and reproducible electrophysiological technique for the evaluation of sympathetic nervous system function[2,24]. The SSR has been defined as the change in electrical potential of the skin. It is mediated by a pathway, which includes the afferent myelinated fibers, the central nervous system, the efferent pre-and postganglionic sympathetic C fibers, and the neuroglandular junctions[11,24]. The SSR has been used by several investigators in assessment of different pathologies and to determine the effect of different modalities on sympathetic nervous system[13,16,29,30].

The current study was conducted to determine objectively the effect of low intensity laser therapy on sympathetic activity in healthy subjects, through measuring

changes in SSR amplitude following exposure to helium neon laser irradiation.

MATERIALS AND METHODS

Subjects

A total of forty healthy males with age 24:30 years (mean 27 ± 1.7 years) participated in the study. The subjects were selected from members of the Faculty of Physical therapy, Cairo University. Subjects were free from peripheral nerve impairment or disease, which might cause autonomic disturbance. They were refrained from strenuous exercise, cigarette smoking, caffeine, and medications affecting autonomic nervous system for 12 hours before the testing.

The subjects were randomly divided into two equal groups each included 20 subjects. *Laser group*: received low intensity laser therapy. *Placebo group*: received sham laser to eliminate suspected placebo effect.

The study was conducted in February through April 2003, at the electrodiagnosis lab, Faculty of Physical Therapy.

Instrumentation

1- Toennies NeuroScreen Plus electromyograph was used to determine SSR amplitude.
2- ASA laser apparatus was used to deliver the low intensity laser.

Testing procedures

Measurement of sympathetic skin response (SSR) was performed for each subject in both groups pre laser/sham irradiation and post laser/sham irradiation at interval of immediately, 5 minutes, and 15 minutes.

Measurement of sympathetic skin response:

The whole procedures for measurement of SSR were done following Aramaki el al., (1997)[2].

Subjects were placed in supine position in a quiet air conditioned room with temperature controlled 26°C and skin temperature between 32:36°C. The subjects were allowed to rest for 30 minutes before conducting the test.

Each subject was informed about the steps of the test procedures. The areas under the recording and stimulating electrodes were swept with alcohol to decrease skin impedance, and conducting gel was put under the recording electrodes.

- The recording electrodes: two surface recording electrodes, The active electrode was placed on the palm of the left hand at the level of the third metacarpal and the reference electrode on the corresponding dorsal surface of the left hand. The earth electrode was applied to the right hand.
- Bipolar stimulating electrode was placed on the forehead of the subject for stimulation of the supra orbital nerve. A series of 3 electrical stimuli with constant rectangular waveform and 0.2 ms were delivered at random sequence with at least 30 seconds intervals between stimuli to avoid habituation. The current intensity varied from 10:18 mA.
- Recording were obtained by two channels Toennies NeuroScreen electromyograph equipment. Sensitivity set 1000 uV/ Div, sweep speed 1000 ms/Div and filter setting 0.5 Hz to 2 kHz. Peak to peak amplitude of SSR was determined. Three responses were recorded and the largest amplitude was selected.

Treatment procedures

Laser irradiation

Subjects participated in laser group, received Helium Neon laser. Laser irradiation was delivered to the palm of left hand and up

10 cm above wrist joint line. The following parameters were selected, Helium Neon (He Ne) laser with wavelength (632.8 nm), energy density 1.7 J/cm^2, continuos mode and for duration of 17 minutes[31]. Scanner technique was used. Laser was applied as the subject in supine position.

Subjects in placebo group received shame laser in which laser was applied with the same laser apparatus and the same procedures as in laser group but the laser beam was not activated. Subjects were not aware of the group they were participated.

DATA ANALYSIS

Scores of the SSR amplitude were recorded for both groups pre, immediately post, 5 minutes post, and 15 minutes post laser/sham irradiation. The scores were expressed as mean Standard deviation (SD), difference and percentage of difference (% diff) from pretest scores.

Repeated measure way ANOVA tests were performed for individual group to determine the effect of laser in laser group and placebo effect in placebo group. If there was significant difference in the ANOVA test, further Bonferroni post hoc pair-wise comparisons were conducted to examine differences between each pair of the measurement. Level of significance was set at ($P < 0.05$).

RESULTS

As shown in table (1) and figures (1,2) the mean values of all measurements of SSR amplitude (mV) of both laser and placebo groups are presented. In laser group, laser irradiation resulted in decrease of SSR amplitude from (3.22 ± 0.71) pre laser irradiation to (1.49 ± 0.21) immediately post laser irradiation, (1.66 ± 0.21) 5 min post irradiation, and (2.34 ± 0.39) 15 min post irradiation. While in placebo group which received sham laser SSR amplitude were (3.5 ± 0.68) pre sham laser irradiation, (3.45 ± 0.7) immediately post irradiation, (3.43 ± 0.7) 5 min post irradiation, and (3.53 ± 0.75) 15 min post irradiation.

Table (1): Sympathetic skin response amplitude (mV) of both groups.

	Laser Group (n = 20)				Placebo Group (n = 20)			
	Pre	Post imm	Post 5min	Post 15min	Pre	Post imm	Post 5 min	Post 15min
Mean	3.22	1.49	1.66	2.34	3.5	3.45	3.43	3.53
SD	0.71	0.21	0.21	0.39	0.68	0.7	0.7	0.75
%Diff		-53.7%	-48.4%	-27.3%		-1.4	-2%	0.8%

% Diff : % Difference min: minutes imm: immediately

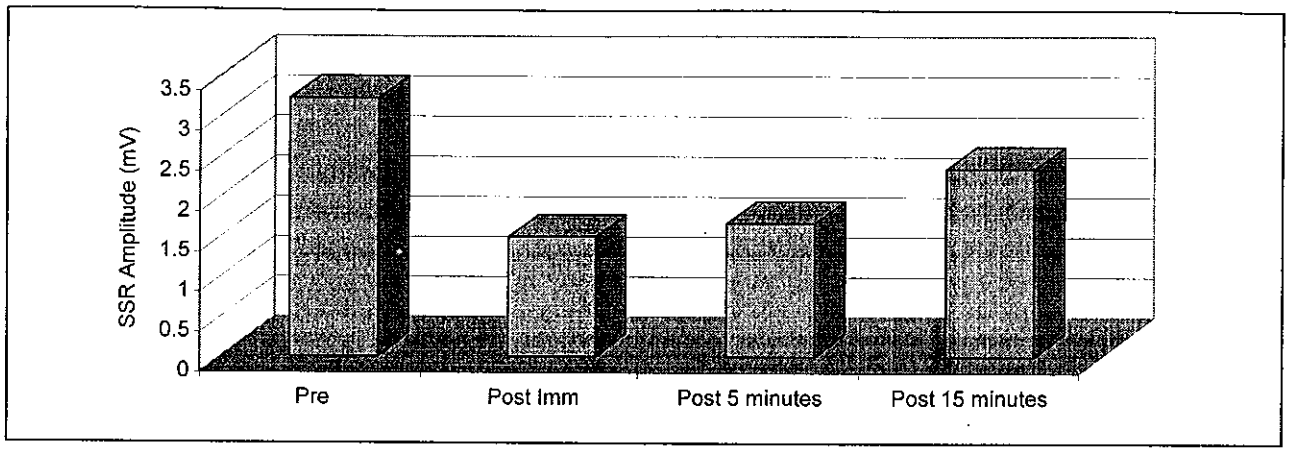

Fig. (1): Sympathetic skin response amplitude of the laser group.

When calculating the percentage of reduction of SSR amplitude of post irradiation measurements as compared to the pre irradiation measurement, laser group demonstrated decrease in SSR by 53.7 %, 48.4 %, and 27.3 % at immediately, 5 min, and15 min irradiation respectively. While placebo group demonstrated change of SSR by -1.4 %, -2 %, and 0.8 % at immediately, 5 min, 10 min and, 15 min post irradiation respectively, table (1).

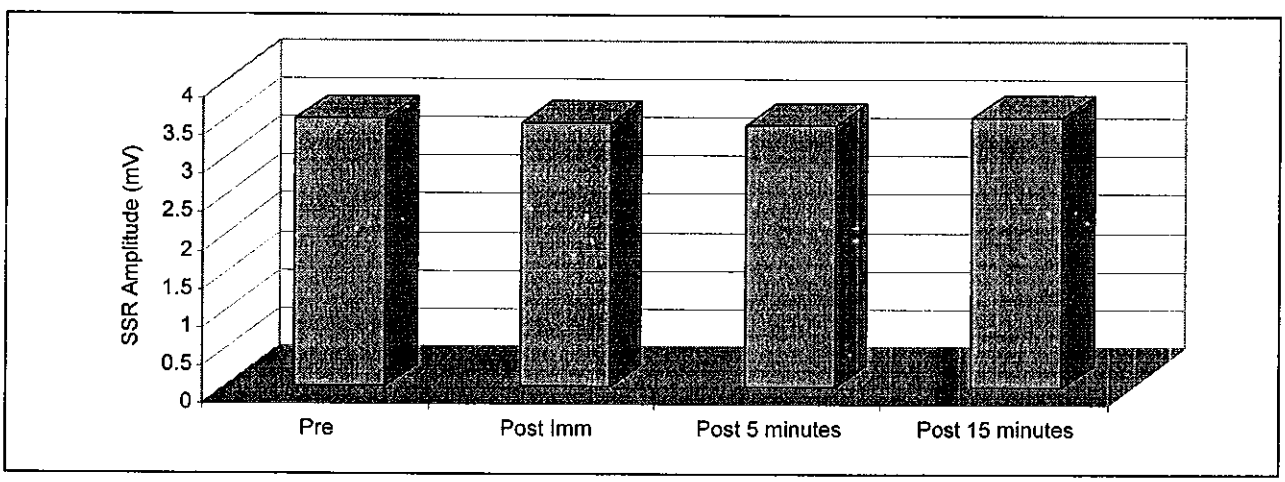

Fig. (2): Sympathetic skin response amplitude of the placebo group.

The results of the one way ANOVA test demonstrated that there was significant decrease of SSR amplitude over time for laser group ($P < 0.0001$) table (2). While there was no significant of SSR amplitude of placebo group ($P>0.05$) table (3).

Table (2): ANOVA table for the effect of laser therapy on sympathetic skin response amplitude of laser group.

Source of Variation	Df	SS	MS	F	P-value
Treatment (between columns)	3	37.272	12.424	48.45	< 0.0001*
Individual (between rows)	19	5.692	0.2996		
Random (residual)	57	8.727	0.1531		
Total	79	51.690			

*Significant

Table (3): ANOVA table of sympathetic skin response amplitude of placebo group.

Source of Variation	Df	SS	MS	F	P-value
Treatment (between columns)	3	0.1304	0.04346	2.41	> 0.05
Individual (between rows)	19	37.856	1.992		
Random (residual)	57	1.027	0.01802		
Total	79	39.014			

*Significant

As there was significant difference of SSR amplitude of laser group further Bonferroni post hoc pair-wise comparisons were conducted. The results revealed that, significant decrease in SSR amplitude at immediately, 5 min, and 15 min (P< 0.001) compared to the pre scores. When comparing between each pair of post measurements there were significant decrease of SSR amplitude of post treatment 15, compared to post immediately (P<0.05), and 5min post (P< 0.001). Also there was non-significant decrease of 5 min post compared to immediately post laser (P>0.5), table (4).

Table (4): Bonferroni post hoc pair-wise comparisons of laser group.

	Mean Diff.	t	P
Pre vs imm Post	1.73	14.02	<0.001*
Pre vs Post 5 min	1.56	12.6	<0.001*
Pre vs Post 15 min	0.88	7.15	<0.001*
Post imm vs Post 5 min	-0.17	1.3	>0.05
Post imm vs Post 15 min	-0.85	6.78	<0.001*
Post 5 min vs Post 15 min	-0.67	5.49	<0.001*

*Significant
% Diff : % Difference
min: minutes
imm: immediately

DISCUSION

Laser has become a routine component of physiotherapeutic treatment. The uses of low intensity laser have steadily grown in the ensuing years. The main indications for LILT in physiotherapeutic practice are wound healing, soft tissues injuries, and pain relief[25]. The LILT analgesic effect was generally accepted in clinical cases, whereas there was no direct evidence to indicate the effect of LILT on sympathetic nervous system[31].

The current study represents an attempt to determine objectively the direct effect of low intensity laser therapy on sympathetic activity through recording changes of SSR after laser therapy. Furthermore, that this study could provide additional evidence of the possible involvement of sympathetic nervous system in laser mediated analgesia.

The results of the current study demonstrated that, He Neon laser with wavelength (632.8 nm) continuous mode, energy density 1.7 J/cm^2 and applied for duration of 17 minutes, produced reduction of sympathetic nervous system activity as evidenced in the significant reduction of SSR amplitude. In addition this reduction continued to a period of 15 minutes after laser irradiation. (see figure 3).

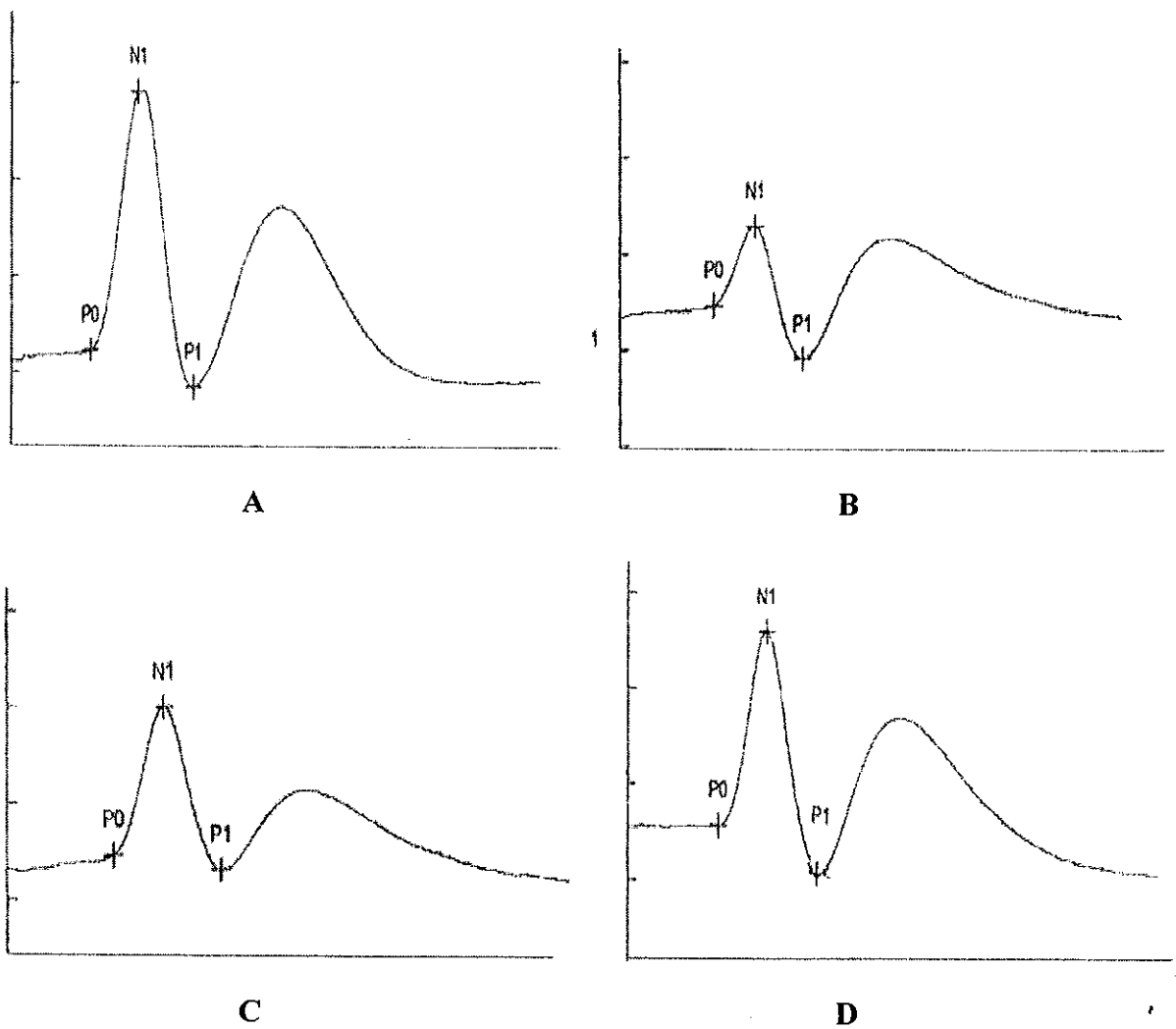

Fig. (3): SSRs amplitude recorded from the laser irradiated hand in the same subject (A) pre laser application (B) immediately post laser application, (C) 5 minutes post application, (D) 15 minutes post laser application.

He NE laser was reported to be effective in pain reduction of different origin either musculoskeletal pain as low back pain[18], and arthritis pain[7, 17] or neurologic pain as nueralgia and radicular pain[6, 27]. The laser parameters used in the study was chosen within what was recommended for treatment of painful conditions specially neurologic pain[31].

The SSR was used in the current study to measure sympathetic activity. The SSR has been established as non-invasive valid technique for assessment of autonomic nervous system function[2]. The SSR was reported to be objective method for measuring sympathetic activity in both normal and pathological conditions[16,29]. This technique has been used by many investigators to determine the effect of different modalities on sympathetic nervous system function[13, 30].

In the present study, the reduction of the SSR amplitude of the subjects in the laser group which received He Neon laser can be attributed to decreased activity of postganglionic sympathetic nerve fibers with direct inhibitor effect on efferent C fibers[9, 32]. So there might be a local blockage of the sympathetic fibers of the seudomotor pathway, which travel along efferent C fibers and which are considered to be the efferent limb of the SSR. On study to determine the pathway of SSR in spinal cord Nair et al reported that SSR pathway include afferent myelinated fibers, the central nervous system, the efferent pre- and postganglionic sympathetic C fibers, and the neuroglandular junctions[26].

In consistence with this explanation Ohtsuka et all (1996) conducted a study to investigate effect of LILT near the stallete ganglion for postherpetic facial neuralgia. It was concluded that irradiation of the stellate ganglion with LILT increase facial blood flow and relieves facial pain. This may be attributed to blockage or decreased sympathetic activity[27].

The LILT was reported to be effective in reducing sympathetically related pain. Several investigations reported significant improvement of Raynaud'S phenomenon after LILT as evidenced clinically and thermographically. It was recommended that LILT might be an effective therapy of the Raynaud'S phenomenon[1, 15, 20]. In spite of indirect relation to our study, these reported investigations could provide additional proof of the effect of laser on SNS.

Furthermore the results of the present study could provide explanation to the reported effect of laser on blood flow. The LILT was found to improve blood flow in the lower limbs in patients with ischemia of the lower limbs and in patients with diabetic microangiopathy[12,28]. As these studies provided no possible explanation, so in light of the current results we could propose that laser may produced reduction of sympathetic efferent nerve fibers activity to peripheral blood vessels leading to vasodilatation and improving blood flow.

The reduction of SSR amplitude occurred in this study can not be attributed to the habituation of SSR. The major problem in measurement of SSR is habituation, which is the decrease of response amplitude due to repetitive stimulation at short duration[8]. As the stimulation were delivered at random order and the interval between each set of stimulation and recording during the study was at least 10 minutes, habituation of the response can not be considered as a causative factor for the resulted reduction in SSR amplitude recorded in the study. In addition Aramaki et al analyze the normal waveform of SSR and reported that the response is triphasic

(negative/positive/negative) and as habituation occur the SSR changed into biphasic configuration[2]. As illustrated in figure (3), the configuration of the SSR recorded during the study was triphasic.

Also the reduction of SSR found in the study can not be related to the placebo effect. Our finding showed that there was no significant change of SSR amplitude of placebo group that received sham laser, which exclude the placebo effect. The design of the study was placebo-controlled design. This design was chosen to eliminate any doubt of the responsibility of placebo effect on the results and to be sure that the resultant change in SSR amplitude was actually due to laser irradiation. In a meta-analysis study conducted by Gam, et al., (1993) to provide a more objective overview of laser therapy. The study was limited to 23 musculoskeletal pain studies. They concluded that the placebo effect could lead to misjudge the reported results especially in the insufficiently blinded studies[14].

Another possible explanation for the reduced SSR amplitude observed after laser therapy is that LILT has inhibitory effect on afferent sensory fibers. Kasai et al, (1996) investigated the effect of LILT on electrically evoked responses within the sural nerve in anesthetized rabbits. They reported that low power laser acts as a direct suppressor of neural activity and impulses conduction of A delta afferent fibers in peripheral sensory nerve, which caused a pain sensation[22]. It was proposed that neural connections exist in the spinal cord between sensory afferent fibers and preganglionic sympathetic fibers[11, 26]. So laser may indirectly affect SNS outflow from the spinal cord by acting on peripheral afferent fibers.

According to all have been presented, the present study sheds light on the effect of LILT on sympathetic activity which encourages more ongoing researches in that area exploring the possible role of SNS in laser mediated analgesia. Furthermore clinically, this study provides additional objective poof of the effect of laser in management of conditions suffering from pain of sympathetic origin and other pathological conditions accompanied with increased sympathetic activity leading to increase vasoconstrictor effect.

CONCLUSION

From this study, it can be concluded that LILT reduces sympathetic activity in healthy subjects. The inhibitory effect of laser on sympathetic nervous system may provide another explanation to the laser mediated analgesia. Further studies on the effect of LILT on pathological painful conditions are recommended. Also further studies to investigate the assumption that LILT could affect sympathetic activity in sympathetically maintained pain are warranted.

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الملخص العربي

تأثير الليزر المنخفض الشدة على نشاط الجهاز السمبتاوى في الأشخاص الأصحاء

أصبح الليزر المنخفض الشدة من الوسائل المستخدمة في مجال العلاج الطبيعي . و لكن حتى الآن لم يتم تأكيد تأثير الليزر على الجهاز العصبي السمبتاوى . تم إجراء هذه الدراسة لدراسة تأثير الليزر المنخفض الشدة على نشاط الجهاز السمبتاوى في الأشخاص الأصحاء. أجريت هذه الدراسة على أربعين شخصا من الأصحاء تتراوح أعمارهم بين ٢٤ و ٣٠ عاما . و قد تم تقسيم العينة إلى مجموعتين: مجموعة الليزر: وقد تم تعريضها إلى الهليوم نيون ليزر ذو الطول الموجي ٦٣٢.٨ نانوميتر على شكل غير متقطع و كثافة طاقة ١.٧ جول/ سم^{٢} لمدة ١٧ دقيقة. و مجموعة العلاج السلبي: وقد تم تعريضها إلى نفس الجهاز بشعاع ليزر غير نشط.

تم قياس نشاط الجهاز السمبتاوى عن طريق قياس استجابة الجلد قبل التعرض لشعاع الليزر و بعد الإشعاع مباشرة و على فترات ٥ دقائق و ١٥ دقيقة بعد الإشعاع.

أثبتت المعالجة الإحصائية للنتائج وجود انخفاض ذو دلالة إحصائية في نشاط الجهاز السمبتاوى في الأشخاص اللذين تعرضوا لأشعة الهليوم نيون ليزر و استمر هذا الانخفاض خلال ١٥ دقيقه بعد التعرض لليزر و كانت نسبة الانخفاض مقارنة بالقياسات الأولية هي كالتالي ٥٣.٧ % بعد الإشعاع مباشرة و ٤٨.٤ % بعد ٥ دقائق و ٢٧.٣ % بعد ١٥ دقيقة. بينما كان هناك تغيير ليس له دلالة إحصائية في نشاط الجهاز السمبتاوى في مجموعة العلاج السلبي . ويستخلص من النتائج أن الليزر المنخفض الشدة يقلل نشاط الجهاز السمبتاوى في الأشخاص الأصحاء. و قد ترجع النتائج إلى إمكانية وجود دور للجهاز العصبي السمبتاوى في التأثير المسكن الناتج عن الليزر. كما تقترح الدراسة إجراء أبحاث أخرى لتقييم استجابة الجهاز العصبي السمبتاوى لأنواع مختلفة من الليزر ذات خصائص مختلفة للوصول إلى افضل تأثير لليزر على نشاط الجهاز السمبتاوى .