

Study of Autonomic Nervous Activity of Night Shift Workers Treated with Laser Acupuncture

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Abstract

Objective: The aim of this study was to evaluate the impact of laser acupuncture on the autonomic nervous system (ANS) of the night shift worker. **Background Data:** Many articles have demonstrated that levels of affective disorders and stress are high in night shift workers. We applied laser energy to the Neiguan point (PC6) to examine the impact of laser acupuncture on the ANS of 45 healthy young males who were night shift workers and evaluated their heart-rate variability (HRV). **Materials and Methods:** The laser group (n = 15) received laser acupuncture (9.7 J/cm², 830 nm) for 10 min, and the placebo group (n = 15) received sham laser treatment. The effects before and after this intervention on the HRV of the subjects were assessed, along with those seen after 30 min of lying down. **Results:** After treatment and after the 30-min rest period, the independent-sample *t*-test showed that both groups exhibited statistically significant differences in high-frequency (HF) HRV, low-frequency (LF) HRV, and the LF:HF ratio of HRV ($p < 0.05$). Compared with the placebo group, the paired-samples *t*-test showed that after laser treatment the treatment group had a statistically significant improvement in HF HRV ($p = 0.001$), LF HRV ($p = 0.001$), and the LF:HF HRV ratio ($p = 0.02$). **Conclusions:** Laser acupuncture stimulation applied to the Neiguan point increased vagal activity and suppression of cardiac sympathetic nerves. This effect was positive and could be used to help patients who have circadian rhythm disorders.

Introduction

A REPORT BY THE SWISS INTERNATIONAL INSTITUTE for Management Development in 2004 revealed that the average number of hours worked per year by workers in Taiwan 2327 hours, which was the third highest in the world.¹ Another survey of social trends in Taiwan showed that 82.18% of the population went to bed between 11 and 12 P.M. and that others did not get to bed until after midnight.² Therefore, many people have difficulty getting up for work in the morning. They may be physically affected by this due to the disruption in their circadian rhythm. Patients with gastric disease, cardiac disease, cancer, diabetes mellitus, low fertility, and sleeping disorders often also have circadian rhythm disorders.³ Some researchers have reported that there is a causal relation between working late and cardiovascular disease in male workers⁴ and female nurses.⁵

Heart rhythm is mainly controlled by the autonomic nervous system (ANS) centered in the brain. The sympathetic nervous system (SNS) releases norepinephrine to activate the sinoatrial (SA) node, while the parasympathetic nervous system (PNS) releases acetylcholine to inhibit it.⁶ In the past, when reading an electrocardiogram (ECG), the focus was on changes in waveform and wavelength. Not until recently has the interval between heart beats, or heart-rate variability (HRV), been studied and considered to be clinically meaningful.⁷ HRV is determined by measuring the changes in the distance between two wave peaks on an ECG, and may be used as an indicator of SNS and PNS activity, and autonomic nervous activity.⁶ HRVs in normal people may be influenced by several factors, such as age,^{8,9} gender,⁹ race,⁸ body fat,⁹ and posture.¹⁰ The analysis of HRV has been developing for more than 20 years, and many different methods have been proposed for data analysis. These methods can be roughly

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classified into linear time domain analysis and frequency domain analysis.¹¹ Our work adopts both analytic methods to evaluate the effects of laser acupuncture on HRV of night shift workers.

Low-energy laser acupuncture that is non-invasive and painless was used in this study. Needle acupuncture usually causes psychological effects and may be painful, which would interfere with ANS regulation. Although there have been some studies in this area and HRV may change during needle acupuncture,^{13–17} the influence of laser acupuncture on changes in HRV has seldom been studied. Compared with needle acupuncture, laser acupuncture is painless, sterile, and safe, and there are no broken needles, no needle-induced illness, and the dose is easily controllable and it is easy to perform.¹⁸ It thus has the advantages of safety and measurability. The aim of this study was to apply laser acupuncture to the Neiguan point of the right hand, and to investigate its influence on ANS regulation and changes in long-term night shift workers.

Materials and Methods

For this double-blind study we recruited 45 healthy young males. Thirty young males worked on the night shift, and they were randomly assigned into laser and placebo groups. All volunteers were recruited in China Medical University Hospital, and the Institutional Review Board on Research on Human Subjects of Chung Shan Medical University Hospital approved this study. Inclusion criteria were young males, aged between 18 and 30 years old, with a body mass index (BMI) between 19 and 25 kg/m², who were night shift workers. Night shift workers are defined as those working until 3 A.M. more than three times a week. Exclusion criteria were having cardiopulmonary or endocrine disease, being on medication, having a smoking history, and having drunk alcoholic beverages in the 24 hours before testing.

Study design

The experiments were conducted in a quiet, closed, air-conditioned (27°C) room between 7 and 10 P.M. Subjects in the laser-treated group laid down for 8 min (Fig. 1) and the non-invasive HRV analyzer were positioned on the left wrist to measure the radial pulse. Then 7 min of HRV were recorded just before the acupuncture treatment (Test 1). Laser energy was then applied continuously to the Neiguan point (PC6) of the subject's right hand for 10 min. After treatment, HRV was again measured for 7 min (Test 2). Next, the subjects had a 30-min relaxation period during which they laid supine. Finally, HRV was measured for another 7 min (Test 3). For the placebo group, the subjects were subjected to the same procedure as those in the laser group, they received 10-min of placebo laser irradiation (the power to the laser was off, but the indicator light remained on). All record-

TABLE 1. DEMOGRAPHIC DATA FOR THE STUDY GROUPS

	Laser group n = 15	Placebo group n = 15
Age (y)	20.27 ± 2.55	21.80 ± 3.08
Height (cm)	171.53 ± 4.47	172.20 ± 4.48
Weight (kg)	68.27 ± 7.35	70.27 ± 9.12
BMI (kg/m ²)	23.20 ± 2.36	23.62 ± 2.25

Data are expressed as means ± standard deviation.

ings were saved inside the HRV analyzer and then transferred to the database in a computer for statistical analysis.

Assessment

The heart rate variability analyzer (ANS WATCH; Taiwan Scientific Corp., Taipei, Taiwan) was used to measure ANS activity. The power spectrum of the signal was estimated from 256 R-R intervals of the heartbeat, and all values were analyzed with HRV analysis software. For the linear time domain analysis, the R-R intervals of the ECG records were analyzed and the results were expressed in the form of normal-to-normal (NN) intervals. Then the standard deviation of the NN intervals (SDNN) was calculated. As for the frequency domain analysis, Fourier transform was applied to complex heartbeat signals so their duration could be determined. Three feature values were obtained, including a high-frequency (HF) value, representing PNS activity, and a low-frequency (LF) value, representing the influence of SNS and PNS activity. Very-low-frequency (VLF) activity has not yet been defined.¹² Linear time domain analysis has rarely been used in spectral analysis, as frequency domain analysis is usually used. This is primarily because the frequency domain type is more appropriate for observing immediate changes in HRV. As established in 1996 by the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, the relevant indices and signals were defined and obtained as follows:⁸

HF: the frequency band from 0.15–0.4 Hz, shown as a percentage

HF (%) = HF power / (HF power + LF power)

LF: the frequency band from 0.04–0.15 Hz, shown as a percentage

LF (%) = LF power / (HF power + LF power)

LF:HF ratio: the ratio of LF to HF HRV

SDNN (ms): the standard deviation of the R-R intervals seen on the ECG

Physiological parameters: systolic blood pressure (SBP in millimeters of mercury), diastolic blood pressure (DBP in millimeters of mercury), and heart rate (HR) (in beats per minute [bpm]).

Treatment procedure

The suggested clinical treatment dosage for the low-energy laser is 8–10 J/cm², and it is used to hasten wound healing.¹⁹ We used a low-energy laser device (Painless Light PL-830; Advanced Chips & Products Corp., Hillside, NJ, USA),

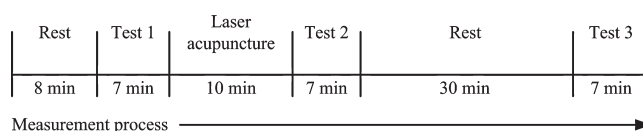


FIG. 1. Protocol used in our study.

TABLE 2. BASELINE DATA FOR THE TWO GROUPS

	Laser group n = 15	Placebo group n = 15	F value	p Value
SBP (mm Hg)	122.07 ± 16.07	121.13 ± 9.43	3.08	0.85
DBP (mm Hg)	76.67 ± 3.24	75.13 ± 2.61	0.72	0.17
HR (bpm)	71.67 ± 11.91	74.07 ± 9.22	1.01	0.54
SDNN (ms)	56.27 ± 23.65	47.00 ± 19.39	1.04	0.25
HF (%)	40.73 ± 15.99	34.47 ± 12.80	1.54	0.25
LF (%)	59.27 ± 15.99	65.53 ± 12.80	1.54	0.25
LF:HF ratio	2.15 ± 2.14	2.28 ± 1.26	1.12	0.85

Data are expressed as means ± standard deviation. F value, Levene's test for equality of variance.

consisting of two infrared diode lasers, to apply the laser therapy. This device emits light at a wavelength of 830 nm, output frequency of 10 Hz, with an output power of 60 mW (2×30 mW), and a duty cycle of 50%, resulting in a treatment dose of 9.7 J/cm². The irradiation was performed with a distance of 2.5 cm between the two laser diodes. The laser treatments were all given by the same physician and were applied to the point of pericardium 6 (PC6), or the Neiguan point. The Neiguan point is located approximately 2 cm proximal to the middle point of the carpal fold between the tendons of the flexor carpi radialis muscle and the palmaris longus muscle.

Statistical analysis

The SPSS software (SPSS, Inc., Chicago, IL, USA) was used to perform the data analysis. The independent-sample *t*-test was used to check for differences between groups in the basic data, such as age, height, weight, and BMI values. Before treatment, after treatment, and after a 30-min rest period, the SBP, DBP, HR, HRV, HF, LF, and LF:HF ratio of both groups were also analyzed using the independent-sample *t*-test. The paired-samples *t*-test was used to compare the parameters of each group before and after treatment. All the statistical tests were two-tailed.

Results

Basic data for our 30 subjects are shown in Table 1. There were no significant differences in height, weight, BMI, and

age between the groups ($p > 0.05$). Baseline measurements (Test 1) of SBP, DBP, HR, HRV, HF, LF, and LF:HF ratio showed that there were no significant differences between the groups ($p > 0.05$; Table 2).

Blood pressure

There were no significant differences in the mean blood pressure values between the two groups after treatment and after the 30-min rest period ($p > 0.05$; Table 3). The comparisons of SBP and DBP before and after treatment, and after the 30-min rest period in each group, are shown in Figs. 2 and 3. Compared with before treatment, there were no significant differences in SBP and DBP after treatment and after the 30-min rest period between the two groups ($p > 0.05$).

Heart rate

The mean values of heart rate showed no significant differences between both groups after treatment and after the 30-min rest period ($p > 0.05$; Table 3). The comparisons of heart rate measurements after treatment and after the 30-min rest period in each group are shown in Fig. 4. A significant improvement was recorded after treatment in the treated group ($p < 0.05$), but none was seen after the 30-min rest period ($p > 0.05$).

Heart rate variability

The comparisons between the two groups for HRV, including SDNN, HF, LF, and LF:HF ratio, are shown in Table

TABLE 3. THE ANALYZED PARAMETERS IN THE TWO GROUPS AFTER TREATMENT

	Test 2				Test 3			
	Laser group (n = 15)	Placebo group (n = 15)	F value	p value	Laser group (n = 15)	Placebo group (n = 15)	F value	p value
SBP (mm Hg)	119.67 ± 7.97	115.00 ± 8.27	0.08	0.13	119.73 ± 12.13	119.00 ± 9.16	2.41	0.85
DBP (mm Hg)	75.87 ± 3.44	76.13 ± 3.16	0.35	0.83	76.60 ± 3.42	76.33 ± 3.04	0.05	0.82
HR (bpm)	66.00 ± 10.60	70.33 ± 8.00	1.13	0.22	65.00 ± 8.90	69.53 ± 8.98	0.003	0.18
SDNN (ms)	81.33 ± 56.00	58.93 ± 27.33	2.27	0.18	111.00 ± 92.11	58.27 ± 22.56	6.92 ^b	0.05
HF (%)	55.33 ± 16.15	35.60 ± 16.26	0.001	0.002 ^a	61.93 ± 12.59	38.13 ± 15.08	2.21	0.001 ^a
LF (%)	44.67 ± 16.15	64.40 ± 16.26	0.001	0.002 ^a	38.07 ± 12.59	61.87 ± 15.08	2.21	0.001 ^a
LF:HF ratio	1.02 ± 0.76	2.35 ± 1.35	7.01	0.003 ^a	0.69 ± 0.41	2.10 ± 1.37	17.81 ^b	0.001 ^a

^a $p < 0.05$ by independent-sample *t*-test.

^b $p < 0.05$.

Data are expressed as means ± standard deviation.

Test 2, after treatment; Test 3, after 30-min rest period. F value, Levene's test for equality of variance.

3. Except for SDNN, comparisons of HF, LF, and LF:HF ratio between the laser group and the placebo group showed significant differences after treatment and after the 30-min rest period ($p < 0.05$). A significant improvement in SDNN was not seen in two-point discrimination in either group ($p > 0.05$; Fig. 5). However, there were significant improvements in HF, LF, and LF:HF ratio after treatment and after the 30-min rest period in the laser group ($p < 0.05$), as shown in Figs. 6, 7, and 8, respectively.

Discussion

This study adopted laser acupuncture instead of traditional needle acupuncture to assess the effects on the changes in HRV of long-term night shift workers. The results suggest that night shift workers need to regulate their biological clocks by manipulating their ANS. Schlager et al.²⁰ reported that night shift workers had more highly activated sympathetic and parasympathetic nervous systems and higher heart rates. Night shift workers need more control and regulation of their autonomic nervous system to accommodate their differing daytime and nighttime schedules. However, an over-excited ANS could be a risk factor for cardiovascular disease.

Acupuncture is a method of physical stimulation of distal nerves in the skin and muscles that excites A α and A δ nerve fibers.¹⁴ The low-energy laser has been used for acupuncture treatment, a method known as laser acupuncture.¹⁸ Odud and Potapenko used laser beams to stimulate acupuncture points to treat hypertension.²¹ Later studies revealed that laser energy in the spectrum from violet to orange (400–600 nm) is more easily absorbed by hemoglobin and melanin underneath the skin, while lasers with wavelengths over 1400 nm are more readily absorbed by water molecules in the skin. As a result, lasers in the red to infrared range (about 600–1400 nm) are the most suitable for acupuncture treatment, because they penetrate 2–5 mm into the skin. In addition, the penetrating ability of laser energy into muscle is four times deeper

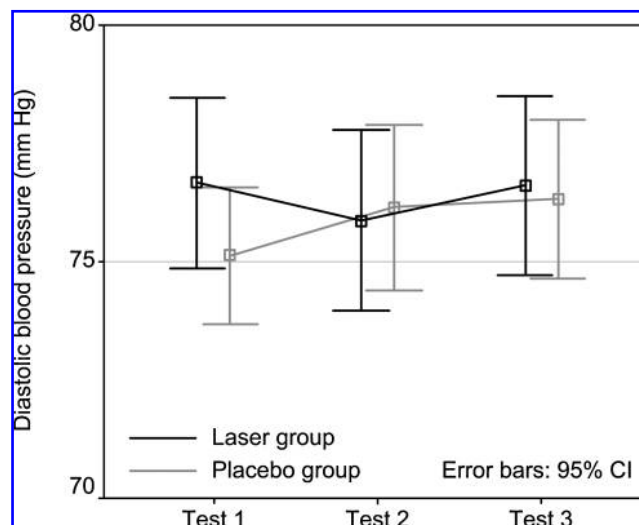


FIG. 3. Paired-samples *t*-test results for DBP values before and after intervention, and after the 30-min rest period, for the three tests.

than that seen in the skin, and therefore the energy can reach nearly 1 cm underneath the skin to stimulate acupuncture points.¹⁸ To date, neural pathways for laser acupuncture remain unknown, but a previous study proved that laser acupuncture can activate areas of the human cortical brain by stimulating acupuncture points. This may lead to a modulation of the neuronal network.²² HRV is a handy tool for clinical evaluation, one that includes HF as an indicator of PNS activity, LF for the combination of SNS and PNS activity, and LF:HF ratio for SNS activity. Nishijo et al. investigated the relationship between needle acupuncture and changes in HR, and found that acupuncture could decrease HR, increase vagal nerve activity, and decrease SNS activity, which lead to increases in HF activity, decreases in LF

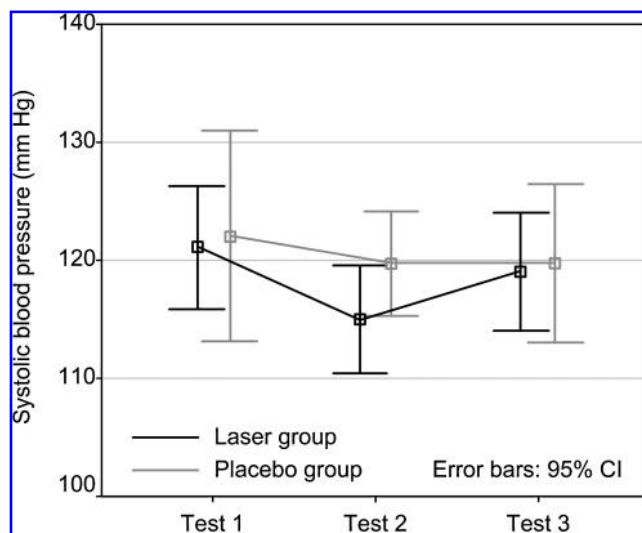


FIG. 2. samples *t*-test results for SBP values before and after intervention, and after the 30-min rest period, for the three tests.

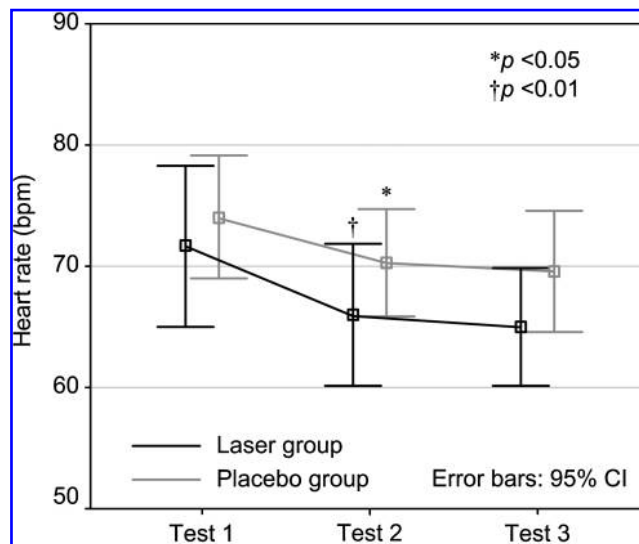


FIG. 4. Paired-samples *t*-test results for HR values before and after intervention, and after the 30-min rest period, for the three tests.

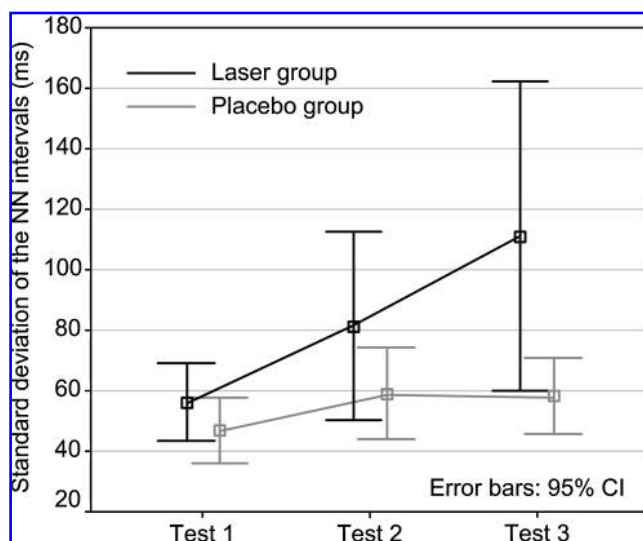


FIG. 5. Paired-samples *t*-test results for SDNN values before and after intervention, and after the 30-min rest period, for the three tests.

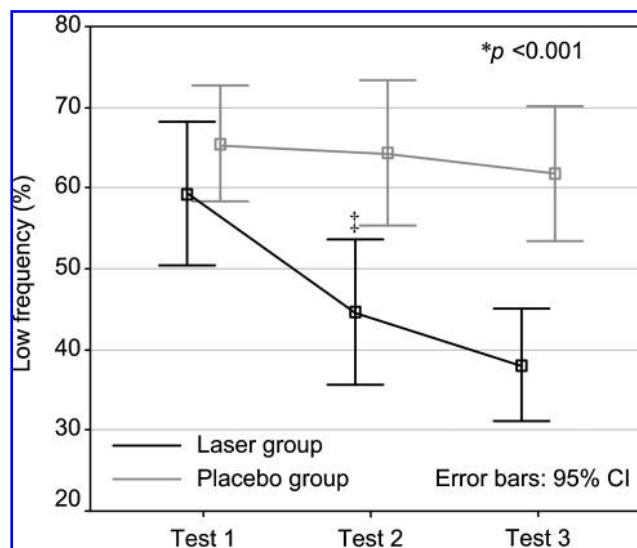


FIG. 7. Paired-samples *t*-test results for LF values before and after intervention, and after the 30-min rest period, for the three tests.

activity, and a decreased LF:HF ratio.²³ The subjects in our study also had higher HF activity, lower LF activity, and lower LF:HF ratios after laser acupuncture, which suggests that laser acupuncture may have the same effects as needle acupuncture. Adjustments in HR and BP in both groups were detected, but there were no significant differences in HR and BP after treatment and after the 30-min rest period. On the other hand, all subjects in our experiment had clear HR and BP changes after the nearly 1-h rest period, whether they received the laser acupuncture treatment or not. This suggests that lying down for 1 h may be the main contributing factor to the lower HR and BP seen in both groups.

Nishijo et al. found that healthy volunteers receiving needle acupuncture at the Sen-Men point (HT7) had decreased

HR.²³ This again indicates that needle acupuncture may regulate the ANS by activating the PNS and inhibiting the SNS. A study by Haker et al. using needle acupuncture at the Hegu point (LI4) of healthy volunteers found that it activated the PNS and SNS. But they also found that only the PNS was activated by acupuncture treatment at the lung point of the ear.¹³ Liou et al. found that non-acupoint acupuncture and acupuncture at the Neiguan point were no different in changing HRV.²⁴ Huang et al. observed that the PNS was excited by twirling the needle during acupuncture at the Neiguan point, while the SNS was not.¹⁴ Chang et al. found that electrical needling of the Zusanli point (ST36) could activate the SNS.¹⁵ Li et al. found that both the PNS and the SNS were activated by acupuncture needling at the Hegu

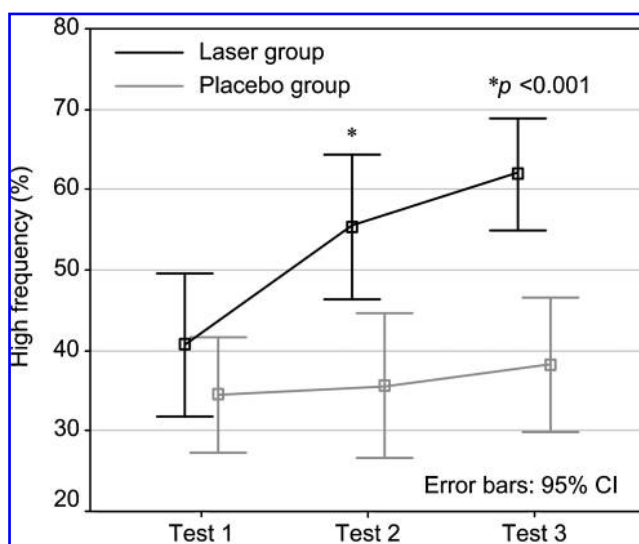


FIG. 6. Paired-samples *t*-test results for HF values before and after intervention, and after the 30-min rest period, for the three tests.

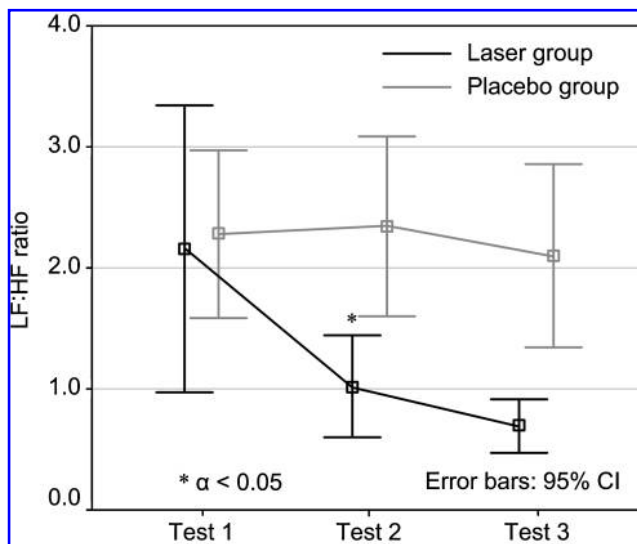


FIG. 8. Paired-samples *t*-test results for LF:HF ratio before and after intervention, and after the 30-min rest period, for the three tests.

(LI4) and Neiguan points, regardless of whether the subjects were fatigued or not.¹⁶ Hsu et al. observed that the PNS was excited but the SNS was inhibited when subjects received acupuncture needling at the Xinshu point (BL15), and suggested a possible relaxing effect of stimulating this point.¹⁷

Needle acupuncture works by stimulation using mechanical impulses sent through connective tissue. This activates signal transduction pathways at acupuncture points and produces changes in ANS modulation.²⁵ We used laser acupuncture to cause similar results via its photobiostimulating effect.¹⁹ Though laser acupuncture has different a physiological mechanism from that of needle acupuncture, it can also affect ANS modulation in night shift workers. In this study, we found that after laser acupuncture at the Neiguan point of night shift workers, the PNS was excited and the SNS was inhibited, and that after a 30-min rest period, excitation of the PNS and inhibition of the SNS were maintained. There were also changes in HRV. These results indicate that laser acupuncture at the Neiguan point of night shift workers can induce a new balance in the ANS, which is maintained for at least 40 minutes. Thus laser acupuncture at the Neiguan point had effects on ANS modulation in night shift workers.

Conclusion

Working at night causes autonomic dysfunction, such as excitation of the SNS and inhibition of the PNS. Long-term imbalances in the ANS may lead to various cardiovascular and other chronic diseases. In this study we found that using laser acupuncture at the Neiguan point (PC6) excites vagal nerve activity and inhibits SNS activity of night shift workers, and helps to adjust autonomic nervous balance. The effect was maintained for at least 40 min after treatment. Thus laser stimulation of the Neiguan point appears to have an effect on ANS balance. We believe this phenomenon requires further investigation to clarify our knowledge of these effects.

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