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A Comparison with Laser Needle, Conventional TENS, and Acupuncture-like TENS upon Pain and Blood Flow in Healthy People

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Objective: Transcutaneous electrical nerve stimulation (TENS) is a treatment method for pain, and it can be divided into conventional TENS (C-TENS) and acupuncture-like TENS (A-TENS). More recently, high power lasers have increasingly been used to reduce pain caused by arthritis, residual neuralgia, and musculoskeletal disorders. The aim of this study was to compare the laser needle with C-TENS and A-TENS in terms of pain and blood flow in healthy people, as well as to confirm that the laser needle can replace TENS to treat pain.

Design: A randomized controlled trial.

Methods: The selected participants were divided using Minimize computer software into a laser group (n = 13), a C-TENS group (n = 13), and an A-TENS group (n = 14); they underwent a pre-test for blood flow and pain in their forearm. The three groups received their respective interventions; they then underwent a second pain and blood flow test on the same spot.

Results: No significant differences were observed in the A-TENS group between the pre- and post-tests, and a comparison among the three groups revealed no significant differences between the laser needle group and the C-TENS group in terms of pain. Regarding blood flow, no significant differences were found between the pre- and post-tests in the laser needle group; a comparison among the three groups only revealed a significant between the laser needle and A-TENS groups.

Conclusions: This study confirmed that the laser needle can be used to treat pain when it is necessary to control blood flow.

Key Words: TENS, Conventional TENS, Acupuncture-like TENS, Laser needle, Blood flow, Pain

Introduction

Every year, more than 7,000 Americans experience acute pain, recurrent pain, and chronic pain, and 10% of the United States population experiences pain for at least three months of the year [1]. Traditionally, clinicians have used drugs and surgery to treat acute and chronic pain as necessary. Indeed, such treatments can control pain for a long time. However, they also have many shortcomings [2].

Recently, many non-invasive treatments have been developed that have minimal side effects and are non-poisonous and one such treatment that is widely used is called transcutaneous electrical nerve stimulation (TENS). In normal conditions, TENS can be divided into conventional TENS (C-TENS), acupuncture-like TENS (A-TENS), pulse train, short and strong stimulation, and slow TENS [3]. In particular, studies have addressed the inhibition of afferent activity, which inhibits harmful stimuli on the spinal cord and functions both up- and down-stream of the synaptic inhibition. Furthermore, researchers have also analyzed blood flow [3], which is regulated by the sympathetic nervous system; specifically, during the pain response, vasoconstriction is inhibited.

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In addition, many investigators have evaluated peptide secretion from sensory neurons, the pump action of muscle contraction, and so on. All of these phenomena are affected by TENS [4].

The abirritation mechanism of high frequency, low intensity TENS (C-TENS) involves the Aβ big fiber, the Aδ fiber, and the C-fiber; it also depends on relative activity between tiny fibers. The conduction velocity of the Aβ fiber is high, while those of the Aδ and C fibers are low. The activity of small fibers causes the nerve impulse to open the gates and spread out. However, if this activity is controlled, the gateways are closed and the participant does not perceive pain [5].

Low frequency, high intensity A-TENS activates Aδ and C fibers, producing counter-irritation analgesia by recruiting descending inhibition mechanisms [6]. Moreover, A-TENS pain modulation is associated with endogenous opiates, which are released as part of the descending inhibitory pathways in response to afferent activity in the Aα fibers [7], whereby inhibition of neural pathways in the dorsal horn is mediated by the rostral ventral medulla [8]. To activate this response, stimulation must be at intensities capable of inducing forceful phasic muscle contraction; usually, such intensities are as high as the patient can tolerate.

Recently, high power lasers have increasingly been used to reduce the pain associated with arthritis, residual neuralgia, musculoskeletal disorders, and so on [9]. Several protocols for this technique have been published, and three major pain-regulation mechanisms have been proposed. In the first suggested mechanism, the neurotransmitter serotonin, or endogenous opiate, is released to regulate pain [10]. In the second, the technique regulates pain by increasing the pain threshold [11]. In the third potential mechanism, the treatment affects sensory nerve conduction to regulate pain [12].

On a different note, little research has been conducted on the relationship between blood flow and pain, and the effects of these two factors on each other are not known clearly. Therefore, in this study, we aimed to ascertain the effect of the laser needle, A-TENS, and C-TENS on pain and blood flow, as well as to provide information as to whether the laser needle could be used clinically.

Methods

Participants

The participants of this study were 40 students in S University. None of them had any abnormal reaction to either laser or TENS. We excluded those with blood circulation disorders, pain, fractures, and sensitive skin. The selected participants were divided using Minimize ™ computer software into the laser (n = 13), A-TENS

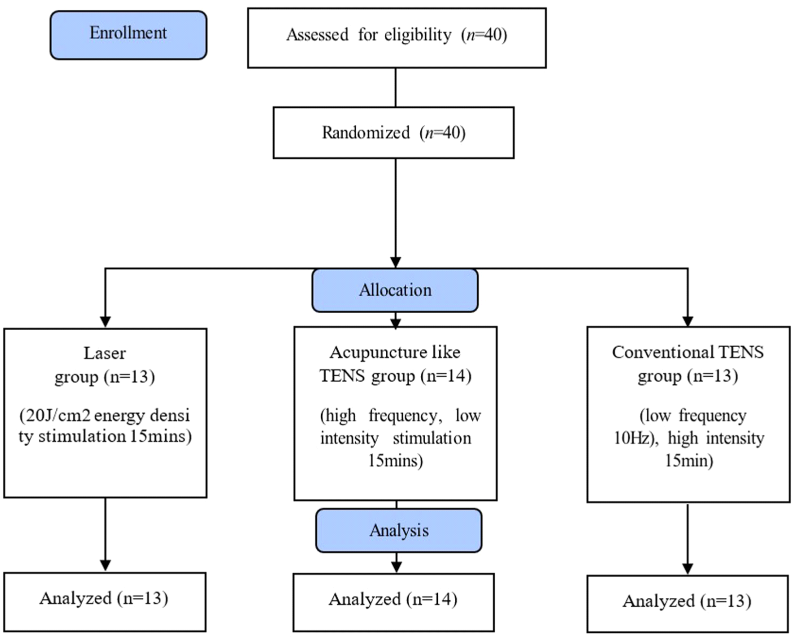

Figure 1. Experimental diagram

group (n = 14), and C-TENS groups (n = 13). All the participants were informed of the purpose and procedures of the study, and those who voluntarily signed the research participation agreement were enrolled as participants.

Procedure

Before the experiment, participants completed a questionnaire as to their common characteristics (sex, age, height, weight, *etc*.). The participants were then randomly divided into the three groups and underwent the pre-test for blood flow and pain on their forearm. The groups were given their respective interventions separately; they then underwent the post-test for pain and blood flow on the same spot.

The laser needle

We used the laser needle system (GmbH, Germany) for laser stimulation. The participants sat on a chair comfortably and put their arm on the rail. We stuck the laser needle into their upright forearm and administered a stimulation with an energy density of 20 J/cm^2 for 15 minutes.

Conventional TENS

The two-channel TENS (TENS 7000; Koalaty Products Inc. USA) was used for C-TENS. Volunteers sat on a chair comfortably and put the arm on the rail. We stuck the electrodes (5 cm^2) onto their forearm and applied a high frequency, low intensity stimulation for 15 minutes. Before the treatment, to test the participant's vibration perception threshold, we gradually increased the stimulation, starting at 0.01 mA, until the participant could sense the stimulation. In the treatment proper, we used 90% of this threshold stimulation amplitude.

Acupuncture–like TENS

The two-channel TENS (TENS-7000; Koalaty Products Inc. USA) was used for A-TENS. Volunteers sat on a chair comfortably and put their arm on the rail. We stuck electrodes (5 cm^2) onto their forearm and applied a low frequency (10 Hz), high intensity (the amplitude at which muscle contraction occurs) stimulation for 15 minutes; we controlled the stimulation at all times depending on the pain the participant felt.

Outcome measurements

Blood flow

Laser Doppler imaging was used to measure blood flow to the surface of the skin; it is a non-invasive and dynamic approach. This new blood flow measurement equipment has been used in many fields, such as rheumatism. The participant sat and raised their arm to the lateral rotation position; we marked a point on the belly of the flexor muscle—5 cm inside the central elbow area—and used the laser Doppler imager (Moor LDI2-IR; USA, 2013) to measure blood flow. Before calibration, we set a speed of 10 ms/pix to measure blood flow; we analyzed this on 3 cm × 3 cm images.

Pain threshold

The commander algometer (JTECH Medical, USA) can objectively and repeatably measure and quantitate topical pain in terms of pressure. The pressure pain threshold is the average of the two measurements, which were obtained 0.5 cm from the point we had marked. Participants accepted pressure until they felt discomfort or pain, or until they made an exclamation, such as "ah". We arranged the measurement site in the vertical position and used the average of three measurements. The threshold for the intra-group reliability of digital pressure gauges is 0.75.

Statistical Analysis

All operations of this study and statistics used SPSS19.0 to work out average value and mean deviation. For Normality Test, Kolmogorov-Smirnov test was used. For comparing with 3 groups, One-way repeated measure ANOVA was used. All significance level was 0.05. If significant verification to appeared, Bonferroni will be used as post verification.

Results

General Characteristics of the Participants

There were no significant differences among the groups in any of the parameters. Furthermore, the two groups did not differ significantly in terms of baseline values ($p > 0.05$; Table 1).

Comparison of pain before the intervention with that after

The pain before the intervention differed significantly from that after the intervention in the laser needle and C-TENS groups. However, there were no significant differences in the A-TENS group in this regard ($p < 0.05$; Table 2).

Comparison of blood flow before the intervention with that after

Blood flow before the intervention differed significantly from that after the intervention in the A-TENS group. However, there were no significant differences in the laser needle and C-TENS groups in this regard ($p < 0.05$; Table 3).

Discussion

In the present study, the three groups all showed significant differences in respect of pain; the laser group had the most significant difference.

Laser needle treatment is defined as low intensity, thermal laser irradiation of traditional acupuncture points; therefore, its effects are similar to those of acupuncture. Studies show that acupuncture can stimulate the body to release a variety of neurotransmitters, including peptides; this explains how acupuncture regulates pain perception and the pain threshold. Ethel et al. have shown that laser acupuncture affects all phases of acetic acid and formaldehyde-induced injuries;

Table 1. General characteristics of subjects ($N=40$)

	Laser group (n=13)	A-TENS group (n=14)	C-TENS group (n=13)	*p*
Gender (male/female)	(5/8)	(8/6)	(9/4)	NS
Age (year)	21.15±0.37	21.07±0.26	21.38±0.50	NS
Height (cm)	164.92±7.30	167.92±6.92	169.30±6.81	NS
Weight (kg)	59.46±10.50	62.57±8.66	63.84±7.79	NS

Note. A-TENS = Acupuncture-like Transcutaneous electrical nerve stimulation; C-TENS = Conventional Transcutaneous electrical nerve stimulation; NS= non-significance.
Values were expressed as mean ± standard deviation.

Table 2. Changes in pain by method ($N=40$)

		Laser group (n=13)	A-TENS group (n=14)	C-TENS group (n=13)	*F*(*p*) Post hoc
Pain (N)	Pre	53.60±26.71	58.05±25.02	63.61±23.50	0.519(0.599)
	Post	65.46±25.24	52.32±19.95	75.74±23.31	
	Post-Pre	11.86±7.63	−5.73±11.92	12.13±14.27	10.611(0.000) A∣B B∣C
	t(p)	−5.609(0.000)	1.800(0.095)	−3.064(0.010)	

Note. A-TENS = Acupuncture-like Transcutaneous electrical nerve stimulation; C-TENS = Conventional Transcutaneous electrical nerve stimulation; N = newton.
Values were expressed as mean ± standard deviation.
A = Laser group
B = A-TENS group
C = C-TENS group

Table 3. Changes in blood flow by method (*N*=40)

		Laser group (n=13)	A-TENS group (n=14)	C-TENS group (n=13)	*F*(*p*) Post hoc
Blood flow (mm/s)	Pre	88.68±34.83	96.60±20.77	101.00±17.36	0.659(0.524)
	Post	88.84±46.47	148.87±56.44	117.75±27.07	
	Post-Pre	−0.83±33.42	52.27±55.31	16.75±19.68	6.360(0.004) A｜B
	t(p)	0.090(0.929)	−3.536(0.004)	−3.069(0.010)	

Note. A-TENS=Acupuncture-like Transcutaneous electrical nerve stimulation; C-TENS=Conventional Transcutaneous electrical nerve stimulation.
Values were expressed as mean ± standard deviation.
A=Laser group
B=A-TENS group
C=C-TENS group

that is, it can reduce the activation of peripheral nociceptors, as well as inhibit the release of the nociceptive inflammatory mediators [13].

Many studies have researched the effect of the laser needle on lower back pain, and a lot of factors may contribute to the overall improvement after the intervention, including the placebo effect [14]. Nonetheless, a study by Shin [15] suggested that laser acupuncture can alleviate pain, and that it is a treatment option in lower back pain. Furthermore, Glazov et al. [16] compared pain and disability between sham and laser groups for 6 weeks. They found that laser acupuncture that uses an energy density of 0–4 J/cm^2 to treat chronic, non-specific lower back pain resulted in clinical improvements that are unrelated to laser stimulation.

With regards to research on the intensive effect of pain perception, Chung et al. (1984) reported changes with different frequencies of application, and another study suggested that the C-TENS analgesic mechanism functions through intrinsic β-endorphin substance [17]. In the present study, neither the laser needle group nor the A-TENS group showed significant differences in terms of blood flow.

Some studies have shown that low level laser therapy stimulates the proliferation of glial cells and fibroblasts. Vinck et al. [18] used green light emitting diodes for three consecutive days to irradiate chicken embryo fibroblasts at an energy density of 0.1 J/cm^2. This led to artificial development in culture mediums that contained high glucose concentrations. In the same study, using the MMT method, the researchers showed that the cell increment rate of the irradiation group was significantly higher than that of the control group. Moreover, this increased cell activity was one of the main causes of the increased blood flow.

Former studies have also shown that, in TENS stimulation under the pain threshold, there is significantly increased blood flow to the muscles. This is not due to the electrical stimulation itself, but by the temperature increase conferred by the PPG probe [19]. Another study [20] showed that the stimulating effect of below-threshold TENS does not end with the stimulation; rather, a temperature control effect is also delivered. Miller et al. [21] showed that vasodilation caused by the muscle contraction induced by electricity lasted slightly longer than that caused by independent muscle contraction.

In this experiment, C-TENS increased blood flow to a certain extent, but there were no obvious differences with the other group in this regard, perhaps because C-TENS electrical stimulation can increase cell activity without causing muscle contraction.

The limitation of this study is that the sensation of pain is influenced by (1) sex, (2) psychological reasons (effects of family, expectations, emotions, educational background, and so on), (3) experimental variability (methods of causing pain, translation of knowledge, individual error, and so on) [22]. Finally, we only studied the effect in healthy people; future studies into the effect of the laser needle in different patients with pain will be necessary to ascertain the optimum number of treatments.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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