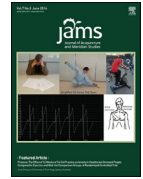


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Journal of Acupuncture and Meridian Studies

journal homepage: www.jams-kpi.com

RESEARCH ARTICLE

Use of Pupil Size to Determine the Effect of Electromagnetic Acupuncture on Activation Level of the Autonomic Nervous System



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Available online 19 April 2014

Received: Jun 11, 2013
Revised: Jul 9, 2013
Accepted: Aug 27, 2013

KEYWORDS

acupuncture point;
electromagnetic
acupuncture;
pulsed electromagnetic
fields;
pupil size variability

Abstract

Magnetic fields are widely considered as a method of treatment to increase the therapeutic effect when applied to acupoints. Hence, this study proposes a new method which creates significant stimulation of acupoints by using weak magnetic fields. We conducted this experiment in order to confirm the effect on the activation level of the autonomic nervous system by measuring pupil sizes in cases of stimulation by using manual acupuncture and electromagnetic acupuncture (EMA) at BL15. We selected 30 Hz of biphasic wave form with 570.1 Gauss. To confirm the biopotential by the magnetic flux density occurring in EMA that affected the activation of the autonomic nervous system, we observed the biopotential induced at the upper and the mid left and right trapezius. We observed a significant decrease in pupil size only in the EMA group ($p < 0.05$), thus confirming that EMA decreased the pupil size through activation of the parasympathetic nerve in the autonomic nervous system. Moreover, we confirmed that the amplitude of the biopotential which was caused by 570.1 Gauss was higher than $\pm 20 \mu\text{A}$. Thus, we can conclude that EMA treatment successfully activates the parasympathetic nerve in the autonomic nervous system by inducing a biotransformation by the induced biopotential.

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1. Introduction

Chinese medicine treats various lesions by making meridian's Qi flow smoothly by performing manual acupuncture. In other words, it is believed in Chinese medicine that diseases are evoked due to imbalance in the body that is caused by Qi stagnation. In a healthy body, Qi flows smoothly throughout the body through meridians. To cure the imbalance, manual acupuncture is performed to release stagnant Qi [1]. Therefore, various researchers investigated the objective treatment mechanism of manual acupuncture, and reported varied research results regarding activation of nerves or internal secretion, and effects on cerebrospinal fluid [2–4]. Moreover, the effectiveness of manual acupuncture treatment was also reported for osteoporosis [5], hyperlipidemia [6], and pain relief [7]. However, patients avoid manual acupuncture because of its invasiveness. Thus, patients are recommended to receive the transcutaneous electrical nerve stimulation (TENS), which only stimulate local parts such as acupoints [8,9].

Numerous studies reported the possibility of using weak magnetic fields as an alternate treatment method [10,11]. Magnetic fields are applied to treat various illnesses such as fractures, pain, arteriosclerosis, and Parkinson's disease, and the method is proven to be most effective in treating neurologic diseases [12–14]. Thus, it is possible to induce curative influences on various lesions using weak magnetic fields. However, weak magnetic fields do not create enough stimulation on an acupoint located deep beneath the subcutaneous tissue because the magnetic flux density generated decreases geometrically according to the distance.

Hence, it is impossible to stimulate an acupoint located deep in the muscular tissue, not in subcutaneous tissue. For this reason, many clinical treatments have been performed with electro-acupuncture (EA) and not with invasive treatment methods, and it was reported that it is more effective than manual acupuncture due to additional stimuli [15–17]. However, EA is still used by most of the clinics because noninvasive methods are limited in terms of how deep they can penetrate. However, EA has a critical problem in that it requires two electrodes because of a potential difference in the current flow. Thus, it is necessary to suggest a new method that can stimulate vertically only at acupoints in order to penetrate deeply into the tissue and generate bioelectric currents without another electrode and external current supply. Thus, this paper proposes a new method which creates significant stimulation on acupoints with weak magnetic fields in similar forms of EA. As solenoid forms of magnetic fields generate magnetic flux from the core, it is possible to stimulate deeper parts rather than simply stimulating an acupoint when electromagnetic acupuncture (EMA) with a manual acupuncture needle for substitution for core is used. In addition, it could increase the therapeutic effect by inducing the reaction inside the body with both manual acupuncture and magnetic fields as reported in the past. Moreover, after the magnetic fields penetrate into an electric conductor such as the body, bioelectric currents can generate eddy currents in the tissue and impact various tissues such as the nerve or muscular tissue, etc., without another electrode.

In order to objectively observe the degrees reflected on the activation of autonomic nerve systems by manual acupuncture on an acupoint, electroencephalogram (EEG), heart rate variability (HRV), skin conductance response (SCR), and pupil size variability (PSV) were observed [18,19]. Two soft muscles that control the size of pupils are directly influenced by the sympathetic nerve of the autonomic nerve system and cause antagonism of the parasympathetic nerves. Therefore, PSV is a better method of observing activation information of the autonomic nerve system. Accordingly, research regarding the interrelationship of activation of autonomic nerve systems from PSV have been conducted previously and identified varied results such as activation of the parasympathetic nerve by drowsiness or fatigue, activation of the parasympathetic nerve by contraction mechanisms induced by cold stimulation, etc. [20–24].

Accordingly, a coil where a manual acupuncture needle can be inserted was produced to observe and analyze the effect of manual acupuncture and EMA on the autonomic nerve system. Also, an eight-channel system was designed in order to stimulate many acupoints at once. In addition, the range of pulsed electromagnetic fields (PEMFs) and extremely low frequency (ELF \leq 300 Hz) were selected as they were proven to have therapeutic effects on the nerve system by making depolarization of adjacent nerves after creating eddy currents as they penetrate into the human body. A pupillometer was designed using an infrared camera to measure the pupil size precisely and sequentially. Then, the activation level of autonomic nerve system was evaluated by measuring the pupil size when performing manual acupuncture and EMA on bladder meridian about BL15.

Existing neurological research established that spinothalamic tract cells are hardly activated by an input on the skin creating stimulation in the heart and the lung. However, it is reported that they are stimulated significantly when the cells get additional input from muscles [25,26]. Therefore, we observed the induced biopotential by magnetic flux density occurring in EMA to study the effect on the muscle, and analyze the effect on the activation level of the autonomic nerve system.

2. Materials and methods

2.1. Selection on an acupoint

In the central nervous system, 12 pairs of cranial nerves, 31 pairs of spinal nerves and autonomic nervous systems, which control an endocrine gland of involuntary muscles and blood vessel systems, pass through the spinal cavity. T1–4 (thoracic vertebrae) affects cardiovascular and respiratory activity [27]. When the patient is in a stable condition, activation of the parasympathetic nerve and stabilization of the autonomic nerve increase the function of the cardiovascular system by relaxation of the body through overcoming stress and bathypnea (deep breath). Therefore, BL15 of bladder meridian was selected as it represents a heart according to meridian.

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