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# Acu-TENS lowers blood lactate levels and enhances heart rate recovery after exercise

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## KEYWORDS

Acu-TENS;  
Blood lactate;  
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**Abstract** *Objective:* The primary aim of this study is to investigate the effect of application of transcutaneous electrical nerve stimulation over acupuncture points (Acu-TENS) on post-exercise blood lactate level. The secondary aim is to explore the effect of Acu-TENS on heart rate recovery and its association with autonomic nervous system.

*Methods:* Twenty healthy subjects (mean age  $26.9 \pm 1.3$ ) acting as their own controls, were randomized to receive either Acu-TENS or Placebo-TENS as the first of two intervention protocols, implemented one week apart. During Acu-TENS, subjects received 45 min TENS bilaterally over the acupoints Neiguan (PC6). Subjects receiving Placebo-TENS had identical electrode placement but with no electrical output from the TENS unit despite an active output light. Interventions were followed by a 10-min ergometer exercise at 70% age-predicted maximal heart rate. Oxygen consumption and heart rate (HR) were recorded continuously throughout exercise. Blood lactate and blood pressure were taken at 4 time points: prior to, immediately after, at 15-min after exercise, and when HR had returned to baseline values.

*Results:* The post-exercise blood lactate level in the Acu-TENS group was lower than that of the placebo group by  $1.12 \pm 0.39$  mmol/L ( $p = 0.01$ ). The Acu-TENS group also had a faster return of HR to pre-exercise level compared to placebo ( $9.98 \pm 4.54$  min,  $p = 0.047$ ). Heart rate variability analysis inferred reduced sympathetic modulation during exercise after Acu-TENS. There was no between-group difference in post-exercise oxygen consumption.

*Conclusion:* Acu-TENS lowered post-exercise blood lactate level and enhanced heart rate recovery after moderate exercise. The role of Acu-TENS in exercise performance and energy metabolism warrants further investigation. (ClinicalTrials.gov Identifier: NCT01102634)

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## Introduction

Energy is provided by adenosine triphosphate during performance of activities of high intensity and short duration<sup>1</sup>; efficient energy metabolism is essential to meet the demand of physical activity at increasing levels of intensity. It is generally believed that when strenuous exercise continues or when there is insufficient oxygen availability to facilitate glycolysis, lactate is produced. However it is now known that lactate facilitates the metabolism of carbohydrates through glycolysis and thus circulating blood lactate should be viewed as a useful form of potential energy instead of a waste product.<sup>1–3</sup>

According to traditional Chinese medicine concepts, the status of body homeostasis is maintained by the balance of energy flow or 'qi'. Other than pain and illness, it has been hypothesized that fatigue caused by vigorous exercise can also disrupt energy flow.<sup>4</sup> Acupuncture, a technique which manipulates the energy flow through insertion of a needle at specific points on the skin (acupoints), has been practiced in China for over 2000 years. Stimulation of specific acupoints has been proposed to improve physical performance,<sup>4,5</sup> but although acupuncture is effective, invasive and adverse effects have been reported.<sup>6</sup> Transcutaneous Electrical Nerve Stimulation (TENS) is a non-invasive modality commonly used for analgesia. Previous studies reported that TENS exerted analgesic effects via similar routes as acupuncture in both animal<sup>7</sup> and human models.<sup>8</sup> We have previously demonstrated that Acu-TENS, application of TENS to acupuncture point PC6 (Neiguan), resulted in a faster return to pre-exercise heart rate compared to a placebo group.<sup>9</sup> Recently we have also shown that application of 45 min of Acu-TENS prior to exercise was associated with less dyspnoea and prolonged exercise duration in both healthy individuals<sup>10</sup> and patients with asthma.<sup>11</sup> The positive effects of Acu-TENS were shown to be associated with an increase in blood  $\beta$ -endorphin level and possibly through effects on modulation of the autonomic nervous system.<sup>10,12</sup>

Examining the relationship between lactate kinetics and exercise performance has led to various lactate threshold concepts due in part to the wide variety of exercise protocols tested.<sup>13</sup> The effect of Acu-TENS on blood lactate level and exercise however has not been explored. This current study aims to investigate the effect of Acu-TENS on blood lactate levels associated with exercise. The secondary aim of this study is to explore the effect of Acu-TENS on heart rate recovery after exercise and to determine if such effect is associated with modulation of the autonomic nervous activity.

## Materials and methods

### Study design

This study adopted a randomized, placebo-controlled, cross-over design and followed the recommended "Standards for Reporting Interventions in Controlled Trials of Acupuncture" (STRICTA)<sup>14</sup> and "Consolidated Standards of Reporting Trials" (CONSORT) guideline.<sup>15</sup> The study protocol was approved by the Human Subjects Ethics Committee

of the involved university prior to data collection. The study procedures were explained to each subject and informed consent was obtained prior to data collection. The sequence of either Acu-TENS or Placebo-TENS as the first intervention protocol was determined by the randomization computer program, "Random Allocation Software" Version 1.0.0 (University of Medical Sciences, Iran). The randomization order was concealed in an opaque envelope until commencement of the study. Data collection and entry were performed by another investigator who was blinded to the intervention. The design is outlined in Fig. 1.

### Experimental procedures

Healthy subjects aged between 20 and 45 years, with no known cardiovascular, pulmonary or musculoskeletal disease, were recruited through an invitation advertisement posted on a university campus. Subjects who responded to the advertisement were invited to the cardiopulmonary laboratory. The study aim and procedures were explained and written consent was obtained from the subjects prior to data collection. Each subject was requested to visit the laboratory on 2 occasions, one week apart. Subjects were advised to refrain from caffeine or alcohol for 12 h and vigorous exercise for at least 2 days, prior to the assessment. Any prospective subject with previous acupuncture experience and those who suffered from recent illness such as upper respiratory tract infection 2 weeks prior to the study were excluded.

Upon arrival at the laboratory, each subject rested in the sitting position for 30 min and baseline measurements (see below) were taken. Each subject then received in random order, either Acu-TENS or Placebo-TENS (identical electrode placement but no electrical output from the TENS unit) for 45 min. Acupuncture points Neiguan (PC6) were identified bilaterally. These points are located 2 "cun" (one cun is the distance between the medial creases of the interphalangeal joints of an individual's middle finger) proximal to the distal crease of the wrist, between the palmaris longus and flexor carpi radialis tendons. The acupoints PC6 were selected in this study because PC6 is a point along the pericardium meridian, a meridian associated with protection and optimization of heart function; this point is often selected for management of arrhythmias and symptoms of heart disorders.<sup>16</sup> Furthermore, PC6 was used in previous studies on investigation of its effect on autonomic nervous system<sup>17</sup> and on investigation of recovery heart rate after exercise.<sup>9</sup>

The skin resistance over PC6 was lowered by cleaning the area with alcohol swab and ECG electrodes (3M<sup>®</sup> Monitoring Electrode 2223, 3M Co., Ltd., USA) were attached over each point. The electrodes were then attached to a TENS machine (ITO ES-120Z, ITO Co., Ltd., Japan) (Fig. 2).

### Intervention stimulation protocols

Acu-TENS protocol: Burst Train Stimulation at a frequency of 2 Hz, pulse width 200  $\mu$ s and at the highest tolerable intensity just short of pain, over acupuncture points Neiguan (PC6) for 45 min before exercise.

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