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RESEARCH ARTICLE

Electromyographic and Strength Analyses of Activation Patterns of the Wrist Flexor Muscles after Acupuncture

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Abstract
This study analyzed the electromyographic and strength responses of the flexor muscles of the wrist following stimulation of acupuncture points. A total of 52 participants were randomly divided into four groups: local (heart 3, HT3), distant (heart 4, HT4), control (bladder 60, BL60), and naïve control groups. To obtain the root mean square electromyographic activity, we placed surface electrodes over the wrist flexors. To obtain kilogram force (kgf) values, we attached a force transducer to the floor and to the hands of participants. Both values were recorded over three repetitions of maximal isometric wrist flexion contractions. Data were analyzed using one-way analyses of variance, followed by Dunnett's post-hoc tests. We found reductions in electromyographic activity contralateral to the stimulated point in the distant group 10 minutes after removal of the needles ($F_{3,48} = 3.25$; $p < 0.05$). Regarding muscle strength, ipsilateral and contralateral stimulation in the distant group produced kgf levels prior to and 10 minute and 20 minutes after withdrawal of the acupuncture needle that were lower than that obtained prior to insertion of the needle ($F_{3,48} = 5.82$; $p < 0.05$). Thus, stimulation of the acupuncture points distant from the wrist flexors reduced ipsilateral and contralateral muscle strength and decreased the root mean square values contralateral to the site of stimulation.

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1. Introduction

Acupuncture is a therapeutic method that has been used in traditional Chinese medicine for over 3000 years [1]. Unlike other procedures that were used in ancient times and are no longer employed, acupuncture has been continuously practiced and is currently one of the most popular treatments worldwide [2–4].

Clinical and experimental studies based on the modern scientific model have demonstrated the efficacy of acupuncture in various biological systems [2,5,6]. Neurochemical, histological, and neurophysiological studies have attempted to elucidate the mechanisms of action of acupuncture [7–10]. These studies have thoroughly documented the release of vasoactive substances, increases in local blood supply, increases in cellular oxygenation, metabolic changes, increases in immune system activation, changes in the lymphatic system [11], and the release of endogenous opiates that promote analgesia and muscle relaxation. Thus, Zhao and Zhu [12] suggested that acupuncture directly affects the peripheral regulation of the release of mediators of inflammation and pain and promotes a reduction in the peripheral release of substance P. Regarding the muscular system, some studies have indicated favorable results in the treatment of conditions that include facial paralysis [13], tension headaches [14], rotator cuff tendinitis [15], and impaired motor responses following stroke [16].

In general, the studies that have sought to investigate the effects of acupuncture on the muscular system have used electromyography (EMG) [17]. This technique enables the identification and description of the function of motor units in terms of muscle activation, and the amplitude and frequency of electrical activation [18]. EMG can be divided into two types: depth EMG in which the electrodes are placed within the muscle in direct contact with the muscle fibers, and surface EMG in which the electrodes are placed under the skin and capture the sum of the electrical activities of all active muscle fibers [19]. Surface EMG is a noninvasive and simple technique that is widely used in kinesiology and muscle neurophysiology studies [19]. Load cells can also be attached to EMG equipment to generate information about the forces produced by muscle contractions [20]. The contractions of the upper trapezius and temporalis muscles after acupuncture have been investigated using this technique, and these investigations have revealed changes in activation patterns [16]. In our laboratory, we have shown that the tibialis anterior muscle exhibits modifications in muscle contraction and force generation following acupuncture [21].

Thus, the aim of this study was to investigate the activation patterns and the strength responses of the flexor muscles of the wrist following stimulation of the heart 3 (HT3; local) and heart 4 (HT4; distant) acupuncture points using surface EMG and load cells.

2. Materials and methods

The participants in this study were 52 right-handed healthy individuals of both genders between the ages of 18 years and 30 years who were recruited through advertisements placed on bulletin boards in classrooms and through electronic invitations. The participants were randomly allocated into four groups. The randomization process entailed the following. After the selection of the overall sample (52 participants), we created 15 sealed envelopes containing the name of each experimental group (resulting in a total of 60 sealed envelopes). Prior to the initiation of the experiment, each participant choose one of the 60 sealed envelopes and were assigned to the corresponding experimental group. Of the four experimental groups, three underwent acupuncture at specific points as follows: the local group (LG) received acupuncture at the HT3 point ($n = 15$), the distant group (DG) received acupuncture at the HT4 point ($n = 14$), and the control group (CG) received acupuncture at the bladder 60 (BL60) point ($n = 15$). The participants in the fourth group, that is, the naïve control group (NCG; $n = 8$) did not receive any acupuncture (Fig. 1). The heart meridian points were chosen based on their anatomical locations and relationships with the wrist flexor muscles. The BL60 acupuncture point was selected because it is located at the end of the lower limb and has no anatomical relationship with the wrist flexors.

The participants received written and verbal information detailing the procedures and read and voluntarily signed consent forms that were written in accordance with Resolution 196-96 prior to the procedures. We excluded participants who did not meet our age criteria, were left-handed, had pain in their upper limbs, had histories of muscle disease, connective tissue disease, uncontrolled epilepsy, immunosuppression, fear of needles, epithelial allergies, and those who were pregnant. The project was approved by the Ethics Committee on Human Research and Experimentation, HCFMRP Protocol number 8864/2010 and is registered in the National System of Information Ethics and Research Involving Human Subjects CAAE-0301.0.004.000-10 as ethically and methodologically appropriate according to the precepts of Resolution 196/96 of the National Health Council.

We used a portable surface EMG machine with six channels (model 400c-200c; EMG System, São José dos Campos, São Paulo, Brazil). The electrodes were active, double, bipolar (with fixed inter-electrode distances), adhesive, and disposable. A force transducer (EMG System) was coupled to one of the channels of the EMG equipment and used as a dynamometer to convert the traction force applied to the load cell to kilogram force (kgf).

EMG electrodes were placed on the muscle bellies of the wrist flexors parallel to the muscle fibers (Fig. 2). The hands of the volunteers were connected to the force transducer to enable the analyses of muscle activation and force during maximal isometric flexion contraction of the wrist as described in the Surface Electromyography for the Non-Invasive Assessment of Muscles (SENIAM) project [22]. In this test, the volunteers maintained maximal isometric contraction for 20 seconds in each trial. A dispersive electrode was fixed to the bony prominence of the left lateral malleolus. The volunteers sat in a chair with both arms in the supine position propped on the chair arms and their trunks supported by the back of the chair. After being positioned, the participants performed three maximal isometric contractions against resistance provided by nonelastic bands that were tied to the wrist flexors and the