Lack of effect of acupuncture on electromyographic (EMG) activity – a randomised controlled trial in healthy volunteers

Liz Tough

Abstract

Background Acupuncture is used clinically to treat muscle spasticity and flaccidity. Claims have been made that acupuncture can affect muscle EMG activity, though there is some doubt about the reliability of these studies. This study’s aim was to examine the immediate effects of acupuncture on the EMG activity of the common wrist extensor muscles.

Methods Thirty five right-handed healthy volunteers, 17 male and 18 female, aged 18-70 years were recruited from a convenience sample. Five subjects provided reliability data, and the remaining 30 took part in the main study. The study was a crossover, within-subject design, with the interventions counterbalanced. The three conditions were genuine acupuncture to LI4 (Hegu) and LI10 (Shousanli) for 20 minutes, with de qi; inappropriate acupuncture to PC3 (Quze) and PC6 (Neiguan) for 20 minutes; and 20 minutes of a no intervention control. All participants received each condition in random order.

The outcome measure was surface EMG activity recorded over the common wrist extensor muscles during a 10 second, sub-maximal, isometric contraction. The average of three readings was used. The reliability of the outcome measurement was assessed in five volunteers selected at random who received repeated EMG recordings without acupuncture.

Results The reliability tests showed the EMG procedure was highly reliable, with an intraclass correlation coefficient (ICC 2,1) of 0.9996 and a standard error of measurement of 0.014mV. In the main study, paired t tests for the effect of the order of the first two interventions showed no detectable carry-over effect. Freidman analysis of variance found no difference between the three conditions (P=0.573).

Conclusion No meaningful change was detected in EMG activity following acupuncture interventions, but this study provides a sound protocol and normative values on which to plan future research.

Keywords

Acupuncture, common wrist extensors, electromyography, randomised controlled trial.

Introduction

Background

The use of acupuncture in the treatment of conditions in which the muscular system is impaired is well established within Chinese clinical practice. For example, acupuncture is commonly used in the treatment of facial spasm and paralysis and is, according to Chinese studies, universally successful.1-3 These claims are diminished, however, by failure to acknowledge spontaneous recovery, the lack of adequate control groups, and the use of poor outcome measures. Researchers, acknowledging such shortcomings and wanting a more direct measure of the effects of needling on muscle activity, have used surface electromyography (EMG) as a quantifiable outcome measure in a few studies. One such study investigated the effect of electroacupuncture (at traditional ‘condition related’ acupuncture points) on 30 patients with post-stroke spasticity, and reported that muscle tone as measured by surface EMG was reduced by half compared with a no treatment control.4 This suggests that acupuncture could be useful clinically in such cases. However, the report does not provide details of the EMG equipment used, how it was applied, and the size and placement of electrodes. This information is
essential, especially when evaluating the activity of small, poorly defined muscles, where contamination of data through cross-talk from adjacent muscles is likely. Therefore, although surface EMG does provide a more objective measure of muscle activity, it needs to be applied with rigour and its use carefully documented to strengthen the validity of any associated outcome.

A search for reports of studies that used direct measurement of the effects of needling on muscle activity revealed three studies using EMG as an outcome measure. The first, investigating the effect of superficial acupuncture at TE5 on 10 patients with tension headache, reported ‘a strong trend’ towards a reduction in EMG activity (recorded immediately post acupuncture) in temporalis and upper trapezius muscles. Here the authors clearly described the experimental procedure although the small sample size restricts the generalisability of the study’s findings.

Two other studies used healthy volunteers. The first, investigating acupuncture’s influence on forearm muscle, tested surface EMG activity at flexor digitorum profundus and superficialis. Only one needle was inserted, but it was not made clear into which muscle it was inserted. No significant change in EMG output occurred post intervention. This is not surprising considering the difficulty associated with ensuring the accurate placement of electrodes on, and insertion of needles into, such ill defined muscles.

The second, testing lumbar paravertebral activity, claimed that (based on EMG recordings) needling muscles in volunteers with asymmetrical paravertebral muscle activity improved the muscles’ synergistic co-ordination. The authors describe collecting EMG data during dynamic movement tests, but fail to explain how they avoided potential contamination of data by ‘movement artefacts’.

Finally, commentaries on two studies published in German dispute the authors’ claim that needling local Stomach channel points increases EMG output in the quadriceps muscle of healthy volunteers, and the quadriceps of patients who have undergone anterior cruciate reconstruction. The results were challenged on the basis of: poorly reported methodology, inadequate presentation of findings and inappropriate use of statistical analysis.

A research proposal was therefore formulated to test the immediate and short term effect of local needling on muscle EMG activity, addressing some of the methodological shortcomings of previous studies. The aim of the study was to test whether acupuncture to points relating to the common wrist extensor muscles caused any immediate change, in either direction, to wrist extensor EMG activity when compared to inappropriate acupuncture and a control. A second aim was to assess the reliability of the measuring tool.

Methods

The three experimental conditions – genuine acupuncture, inappropriate acupuncture and a no condition control – were counterbalanced in a crossover, within-subject design using healthy adults. A parallel study tested the reliability of the outcome measurement, without acupuncture.

Volunteers

Ethical approval was granted by Coventry University School of Health and Social Sciences Ethics Committee and by the East and North Hertfordshire Hospital Local Research Ethics Committee.

Due to constraints on time and resources, convenience sampling was used. Forty volunteers were recruited from flyers placed in four physiotherapy waiting areas, in two sports clubs, on a university notice board and in a school staff room. An outline of the study was given, and the exclusion criteria were included on the flyer and checked by telephone interview before recruitment.

Volunteers excluded from the study were those who: were under 18 years of age; had pain in the upper limb or cervical region; were pregnant or diabetic; had uncontrolled epilepsy; had a history of other systemic and muscle/connective tissue diseases; were known to be immunosuppressed or had a needle phobia or skin allergy.

The sample group consisted of 18 males and 22 females aged 18-70, of whom 28 had no previous experience of acupuncture. Five provided data for reliability assessment, leaving 35 volunteers for the main trial. Each volunteer provided a signed consent form after receiving both a written and oral explanation of the procedure.

The order of conditions received by each subject was randomised using a computer programme. Volunteers were randomised into seven groups – six for treatment conditions and one for reliability (codes:
ABC; ACB; BCA; CAB; CBA; none). The combinations were printed and the codes for each condition placed in envelopes which were shuffled and numbered. Envelopes were opened by the volunteers in numerical order.

**Test procedures**

Changes in muscle length and speed of movement can cause significant changes in EMG recording, potentially introducing measurement error. A sustained muscle contraction was therefore used to reduce this interference, and any generated from movement artefacts at the skin/electrode contact surface. A sub-maximal contraction was used to reduce expectation bias from the volunteer. A crossover, within-subject design was used to reduce possible measurement error due to:

(i) variability in electrode placement
(ii) differences in muscle physiology between subjects
(iii) daily fluctuations in muscle activity, both natural diurnal variation and fluctuations due to activity.

A consultation room was prepared for the experimental process. To reduce potential interference from external artefacts, all electrical equipment not involved in collecting data was removed, telephone points were disconnected and a ‘do not disturb’ sign placed on the door.

The volunteer was seated in a hard backed chair with both feet flat on the floor. The dominant arm rested on a treatment couch with the shoulder in partial abduction and flexion, the forearm in a neutral position and the elbow flexed. A neutral shoulder girdle position was obtained by adjusting the height of the treatment couch. The volunteer maintained the forearm test position while tape was attached to the treatment couch outlining the arm’s position. This guided the volunteer in maintaining a constant position for each EMG recording (Figure 1).

A hydraulic hand dynamometer (Baseline, Bolingbrook, IL 6040) was used to standardise the grip effort required. The effort was set at a sub-maximal level. The dynamometer was held in reverse to allow the subject to read the gauge. As the test was sub-maximal and each subject carried out the same procedure, this variation in equipment use was not thought to be a major drawback. The dynamometer was set as recommended by The American Society of Hand Therapists and held in the dominant hand with the wrist in the neutral position.

Volunteers held the dynamometer in the testing position and were instructed to gently grip the gauge until the dial reached 20lb pressure, which the literature suggested would be easily achieved by people of all age groups. Volunteers were then instructed to relax. Each volunteer carried out a preliminary practice test maintaining the grip pressure for 10 seconds. Then three grip tests were performed, with a two minute rest between tests. The practice testing allowed the volunteers to judge the effort required to achieve the pressure needed and allowed the researcher to ensure the EMG machine was recording correctly.

After skin preparation with 70% alcohol, disposable silver-silver chloride pre-gelled snap on electrodes (10mm diameter recording surface), were placed 15mm proximal and distal to LI10 acupuncture point, in parallel with the muscle fibres, for maximum selectivity and sensitivity. LI10 was located by palpation and its position marked on the skin by the impression of a guide tube.

A reference ground electrode was placed over the medial epicondyle as recommended by EMG protocol. EMG was recorded using the DUAL EMG 200 machine. Raw EMG signals detected by the electrodes were amplified and filtered allowing only signals between 100-250Hz to pass through. A ‘notch filter’ removed any remaining 50Hz
interference which the participant could have been picking up from mains operated equipment. The EMG machine worked in conjunction with a Pico Technology Limited ADC-100 duel channel oscilloscope, which connected the EMG machine to a laptop computer. PicoLog data logging software was used to collect and analyse the EMG data. The programme was set at a sampling rate of 1000Hz over the 10 seconds testing time.

The physiotherapist conducting the research had practised acupuncture clinically for three years. Hwato single use stainless-steel acupuncture needles with guide tubes were introduced slowly, to a depth of 0.1-1.0cun into LI10 and LI4 for genuine acupuncture and PC3 and PC6 for inappropriate acupuncture. A 0.25x40mm needle was inserted at LI10, and 0.25x0.25mm needles at the other three points. If de qi was not felt immediately, it was elicited using needle rotation. The needles were left in situ for 20 minutes with no further stimulation. The volunteer was instructed to keep the arm resting on the couch throughout.

For the no intervention control, each volunteer was simply instructed to rest the arm on the couch for 20 minutes, as with the needle intervention.

Data analysis
The EMG recording in millivolts (mV) was reduced by calculating the root mean square within a predetermined 10 second time frame. The mean of the three EMG recordings taken after each condition was calculated for each participant.

Using SPSS software, reliability data were analysed using an intraclass correlation coefficient, ICC (2,1) and the standard error of measurement.

In the main study, a paired t test was used to assess any order (period) effect between the first two conditions each volunteer received, using mean values calculated for each set of data. Then for the comparison between groups, the Friedman ANOVA test was applied to compare group medians of EMG recordings measured across the three conditions, as these data were not normally distributed.

Results
From the initial 40 volunteers, five were withdrawn from the analysis: data from three could not be used due to equipment failure, and two experienced a marked vasovagal response and fainted within 2-3 seconds of needling.

The mean EMG readings for the three tests on each volunteer were highly consistent (see Table 1). The intraclass correlation coefficient, ICC (2,1), of 0.9996 confirmed an extremely high level of intra-rater reliability. The standard error of measurement was 0.014mV which indicates a strong measure of absolute reliability for the outcome measurement procedure in this study.

To detect any order effect when three conditions were tested, the first two conditions that each volunteer received were analysed as representative. The results in Table 2 show that there was no statistically significant difference between conditions.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.31</td>
<td>0.30</td>
<td>0.29</td>
</tr>
<tr>
<td>2</td>
<td>0.33</td>
<td>0.29</td>
<td>0.32</td>
</tr>
<tr>
<td>3</td>
<td>2.18</td>
<td>2.18</td>
<td>2.18</td>
</tr>
<tr>
<td>4</td>
<td>0.31</td>
<td>0.29</td>
<td>0.31</td>
</tr>
<tr>
<td>5</td>
<td>0.36</td>
<td>0.35</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Results are expressed as mean root mean square EMG values (mV) for three repeated readings at standardised sub-maximal contraction in three tests in five subjects.

Table 2 Results of tests for order (or carry over) effect, comparing first two conditions received

<table>
<thead>
<tr>
<th>Conditions</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genuine acupuncture</td>
<td>10</td>
<td>1.02</td>
<td>0.71</td>
<td>0.849</td>
</tr>
<tr>
<td>Inappropriate acupuncture</td>
<td>10</td>
<td>1.03</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>Inappropriate acupuncture</td>
<td>10</td>
<td>1.20</td>
<td>0.77</td>
<td>0.379</td>
</tr>
<tr>
<td>Control</td>
<td>10</td>
<td>1.15</td>
<td>0.73</td>
<td>0.624</td>
</tr>
<tr>
<td>Genuine acupuncture</td>
<td>10</td>
<td>0.91</td>
<td>0.81</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>10</td>
<td>0.92</td>
<td>0.82</td>
<td></td>
</tr>
</tbody>
</table>

*t test
interventions, indicating no detectable carry over effect. As shown in the data in Table 3 there was no statistically significant difference across the three interventions (P=0.573).

Discussion
This study showed that neither genuine nor inappropriate acupuncture had any immediate effect on the EMG activity recorded at the common wrist extensor muscles in a healthy adult population.

The use of pre-selected genuine acupuncture points and the within-subject study design, coupled with a highly reliable EMG procedure, ensured that the test procedures were applied consistently between volunteers, and that the readings within volunteers were reliable. A carry over effect, that is an inherent risk in crossover studies, was not seen in this study.

Limitations
Many aspects of the methodology were predetermined to improve the reproducibility of the test procedure. However, the lack of flexibility in electrode placement and the use of a pre-set grip pressure did not allow for physical variations between volunteers. Placing electrodes more precisely in relation to a named muscle instead of the acupuncture points, and normalising the muscle activity (ie using a fixed percentage of each individual’s maximum grip) may have provided more accurate data. Intuitively, EMG activity might be expected to correlate with muscle strength; but there are few data to demonstrate this. By normalising a muscle’s activity, a more direct comparison can be made between the EMG values of different muscles. This preliminary testing was not carried out due to constraints on time and resources.

For the conditions being tested, careful consideration was given to the selection of the genuine and placebo acupuncture points. LI10 is considered by some authors to be situated at the motor point for the common wrist extensor group.21 The muscle innervation via the posterior interosseous nerve (C7/8), correlates well with the nerve supply of adductor pollicis (C8/T1) where the second acupoint LI4 is situated. LI4 was chosen to strengthen the effect of the intervention, increasing the afferent input into the spinal cord to change the efferent output at the segment.

In traditional Chinese acupuncture, the use of more than one point along a meridian is commonly accepted as providing a more potent treatment. More specifically, LI10 is used clinically for hemiplegia and atrophic disorders, 21;22 although supported by only limited evidence, therefore the selection of genuine acupuncture points was considered appropriate and sound.

A problem recognised from the outset of the study was finding an adequate sham or placebo control. One accepted procedure is to needle true acupuncture points which are inappropriate to the condition being investigated.23 For this reason, ‘Pericardium’ points traditionally used to treat psychological conditions and nausea were selected. The points were close to the electrodes, therefore credible to the volunteer, and were not muscle points. On reflection, this selection of points may not have been ideal, as this region of the forearm is innervated by the same segmental level (medial cutaneous nerve C8/T1) as the ‘genuine acupuncture’ points. However, finding an area in the forearm with a different segmental supply (when using a two needle technique) proved difficult. The use of superficial acupuncture, involving needle insertion at points away from true acupoints, may have provided a less active intervention.23

Conclusion
In contrast to previous work, this study found that, in a healthy adult population local acupuncture had no immediate or short term effect on muscle EMG activity. EMG seems a reliable assessment tool, though its clinical relevance remains unclear. This study provides a protocol, and normative values for

<table>
<thead>
<tr>
<th>Condition</th>
<th>N</th>
<th>Median</th>
<th>IQR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genuine acupuncture – LI4, LI10</td>
<td>30</td>
<td>1.07</td>
<td>1.45</td>
</tr>
<tr>
<td>Inappropriate acupuncture – PC3, PC6</td>
<td>30</td>
<td>1.18</td>
<td>1.40</td>
</tr>
<tr>
<td>No intervention control</td>
<td>30</td>
<td>1.23</td>
<td>1.36</td>
</tr>
</tbody>
</table>
future research, which could include assessing the effect of acupuncture on pain free pathological muscle tissue.

Acknowledgements
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Reference list
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