Effect of acupuncture at HT7 on heart rate variability: an exploratory study

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INTRODUCTION

HT7 Shenmen is a commonly used acupuncture point in traditional Chinese medicine (TCM) and is often used for the treatment of cardiovascular diseases. Acupuncture is additionally useful in various autonomic disorders. Evidence of clinical efficacy exists for conditions including angina pectoris, atrial fibrillation, cardiac neurosis, insomnia, hypertension, as well as several other cardiovascular and neurological diseases.

Several studies have suggested that acupuncture influences autonomic nervous system (ANS) functions such as blood pressure, pupil size, skin conductance, skin temperature, heart rate (HR) and heart rate variability (HRV).

Some studies have suggested that the main effects of acupuncture include reduced HR and altered HRV.1 HR changes are believed to occur in response to autonomic neural activation or inhibition, which are mediated by the cardiac parasympathetic and sympathetic systems.2 HRV is frequently used to quantify cardiac autonomic regulation.3 We hypothesised that the mechanism of action of acupuncture at HT7 in autonomic nerve-related disorders may be related to the regulatory effects of acupuncture, reflected by HRV.

A number of techniques have been developed to quantify HRV to provide indices of cardiac autonomic regulation in both health and disease,4 5 and several recent studies have explored the mechanisms of action of acupuncture by analysing the effects on HRV.6 7 Cardiac autonomic balance can be measured non-invasively by recording the ECG and calculating HRV using time domain analysis and frequency domain (Fourier) analysis.8 The specific effects of acupuncture on HR and HRV have been investigated under both physiological and pathological conditions.2 9 10

However, a recent systematic review by Lee et al11 concluded that sham-controlled RCTs have variable results and provide no consistent evidence that acupuncture has any specific effects on HRV.

The prevailing trend from such studies suggests that acupuncture can increase cardiac parasympathetic activity and reduce HR.12 13 One review concluded that the evidence strongly suggests that acupuncture can improve HR, despite acknowledging the limitations in the methods of various studies.7 Studies of acupuncture at HT7 have demonstrated mixed results, suggesting that it may increase the low frequency (LF) or high frequency (HF) components of HRV or decrease LF/HF ratio and HR.14 15


CrossMark
Since HT7 is widely used to treat conditions that involve the ANS, we aimed to explore the response of HRV to a single HT7 stimulation with multiple control groups. We controlled for the overall effect with a no acupuncture group, for the effect of stimulation by using a non-penetrating sham at HT7, and for point location using penetrating acupuncture at a sham point. In all groups we used the Actiheart ECG recorder to record short-term HRV of healthy subjects.

METHODS

Participants
All participants were students from Southern Medical University and met the following inclusion criteria: (1) normal ECG; (2) no history of organic or mental illness; (3) normal diet (no addiction to coffee, tea, alcoholic drinks or tobacco); (4) normal sleeping habits; (5) no fear of acupuncture; (6) no coffee, tea or alcoholic drink intake in the 24 h before the study; and (7) no acupuncture treatment in the past month. In all, 120 subjects were recruited and randomly divided into the following four groups using a random number table: HT7 verum acupuncture group; HT7 non-penetrating sham acupuncture group; sham acupuncture point group; and no acupuncture group.

Recording of HRV
The study was conducted in a 20 m² laboratory of acupuncture and moxibustion between the hours of 10:00 and 17:00 at an ambient temperature of 23–27°C.

HRV was recorded using the Actiheart ECG recorder, a commercially available device that serves as a combined HR monitor and movement sensor (Cambridge Neurotechnology, Cambridge, UK). With a total weight of 8 g, it can be clipped onto two standard ECG electrodes. Actiheart is technically reliable and valid compared with standard ECG recordings. The device is easy to use, with little discomfort to volunteers, and the supplied software allows data to be extracted for further analysis. It has a sensitivity of 250 μV and a sampling frequency of 256 Hz. The measurable range of HR is 35–250 bpm.

After a 10 min quiet rest, the skin of each subject was cleaned at the level of the xiphoid process. Electrodes (Ambu blue sensor VL-00-S, Ambu A/S, Ballerup, Malaysia) were attached and connected to the Actiheart. The ECG recorder interface cable was then moved to the left and, while the wire was in a stretched state, the other electrode was attached. HRV was recorded before, during and after the acupuncture treatment. The same laboratory assistant recorded and processed the information from the entire experimental procedure.

Interventions
The same senior acupuncturist provided all the acupuncture treatments.

HT7 verum acupuncture
Volunteers received needling at the left HT7 acupuncture point (on the anteromedial aspect of the wrist radial to the flexor carpi ulnaris tendon on the palmar wrist crease) in accordance with the WHO Standard Acupuncture Point Locations in the Western Pacific Region (figure 1). After the skin was sterilised with 75% alcohol, tube needles (tube: DongBang AcuPrime, UK; needle: Tianxie, 0.25×30 mm, Suzhou, Jiangsu, China) were inserted to a depth of 5–10 mm. After the needle was inserted, the guide tube was carefully removed and the twirling method was used to generate needle sensation. After recording the time using a stopwatch, the needle was stimulated by even manipulation for 1 min (range ±180°, frequency 120 times/min) and then retained for 1 min without any further stimulation. This process was repeated five times, after which the needle was removed and the time was recorded (figure 2).

HT7 non-penetrating sham acupuncture
This procedure was identical to the HT7 verum acupuncture procedure except that British DongBang AcuPrime sham acupuncture needles were used instead of the tube needles in accordance with the manufacturer’s instructions. The handle of the needle was pressed until the tip of the needle was 1 mm out of the tube and just in contact with the skin (figure 3) for 1 min. Next, the pressure was released to allow the tip of the needle to move away from the surface of skin for 1 min. This process was repeated five times before the sham needle was removed (figure 2).

Sham acupuncture point
The location of the non-acupuncture point was on the anteromedial aspect of the wrist ulnar to the flexor carpi ulnaris tendon on the palmar wrist crease (figure 1). The procedure was similar to HT7 verum acupuncture.

No acupuncture
Volunteers did not receive any acupuncture intervention but were asked to lie awake while attached to the Actiheart for 30 min.

Blinding
A single-blind design was adopted in this study. All the volunteers were asked to wear anti-noise earplugs (lot. No. R5A018; Aearo Company, Indianapolis, Indiana, USA) and black goggles (Annan Carbon Technology MRX003-C011; ZheJiang, China) to block noise and vision until the end of the trial.

Data export and processing
HR data were first analysed using standard time-domain and frequency-domain indices using the software supplied by the manufacturer. Time-domain indices included bpm, SD of the normal-to-normal intervals (SDNN), SD of all normal-to-normal intervals (SDANN), root mean square of SD of normal-to-normal intervals (RMSDD) and HRV...
triangular index. Frequency-domain indices included variances in very-low frequency (VLF) (0.0033–0.04 Hz), LF (0.04–0.15 Hz) and HF (0.15–0.40 Hz) ranges and the LF/HF ratio, which were obtained using Fourier analysis. The frequency-domain indices were subjected to logarithmic transformation (ln).

The sampling period was set to 5 min. The selective time span for analysis was 10 min before, during and after the needling procedure. There was a 15 s buffering time between 10 min before and during needling to avoid emotional disturbance while inserting the needles (figure 2). The 10 min time span during needling and after needling was continuous.

**Data processing**

Data from the three time periods (10 min before, during and after acupuncture) were sorted and processed using MS Excel 2010 (Microsoft Corporation, Redmond, Washington, USA). All analyses were performed using SAS V9.2 (SAS Institute, Cary, North Carolina, USA) by a statistician blind to treatment allocation. Descriptive analysis of the data was performed using mean±SD, and an exploratory analysis of the model was conducted with generalised linear mixed models (proc mixed), group for group effect, time for repeated measurements effect, and group×time for interaction. Statistical significance was set at p<0.05.

**RESULTS**

**Baseline information**

Baseline information of the participants is shown in table 1. There were no statistically significant differences among the four study groups in any indices including gender, age and body mass index.

Data generated by the Actiheart ECG and recorded 10 min before, during and after acupuncture are shown in table 2. HR was significantly lower in the no acupuncture group than in all three acupuncture groups at all stages. Four parameters (RMSDD, SDNN, lnLF and lnHF) were all higher during HT7 verum acupuncture than in the three control groups. One additional parameter, VLF, was increased in the verum acupuncture group compared with HT7 non-penetrating sham acupuncture and no acupuncture, but not when compared with (penetrating) acupuncture at the sham point. These differences did not persist, for the most part, after acupuncture. Although several other individual differences between the groups met formal tests for statistical significance, none were meaningful.

**DISCUSSION**

Our results suggest that a single HT7 stimulation increases HRV in the short term, as indicated by higher SDNN (time-domain) and VLF, LF and HF
components (frequency-domain) which represent the two primary approaches for the analysis of HRV. Both time-domain and frequency-domain analysis of HRV are affected by mean HR. Consequently, interpretation of all comparisons with the group not receiving acupuncture are limited by marked differences in HR, possibly associated with procedural anxiety. Nevertheless, it is important in principle to include an untreated control group in studies such as this to allow full interpretation of the changes.

Cardiac autonomic regulation analysis tends to favour frequency-domain rather than time-domain. Accordingly, our results showed that the HF component of HRV was consistently higher during stimulation in the HT7 verum acupuncture group than in the other three groups. HF is mediated by the cardiac parasympathetic nerves and is therefore an indirect marker of cardiac parasympathetic regulation. Therefore, the effect of acupuncture at HT7 may be mediated by cardiac parasympathetic activation. This is consistent with the previous clinical observations of Huang et al. and Wang et al.

We also found that the VLF component of HRV, which is believed to reflect the activity of the sympathetic nervous system, was significantly higher in the HT7 verum acupuncture group than in the HT7 non-penetrating sham acupuncture and no acupuncture groups, but not than the sham acupuncture point group. Similar results have been reported by Kaneko et al., Zhang and Chang et al. The mechanism by which acupuncture increases VLF remains undetermined. The pertinent difference between the sham acupuncture point and no acupuncture groups is that the needle of the former group penetrated the skin, as was also the case in the HT7 verum acupuncture group. Consequently, a higher VLF may reflect the sympathetic response to needling per se, which is arguably a stress response, in the absence of any point specificity.

The LF was also significantly higher in the HT7 verum acupuncture group than in the other three groups. The LF component of HRV reflects both the sympathetic and parasympathetic systems as well as other unidentified factors. The LF was significantly higher before, during and after stimulation in the HT7 verum acupuncture group than in the no acupuncture group, so HT7 verum acupuncture may activate both cardiac sympathetic and parasympathetic systems.

### Table 1 Baseline characteristics of the four groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender M</th>
<th>Gender F</th>
<th>Age (years)</th>
<th>Body weight status*</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>11</td>
<td>19</td>
<td>21.3±0.83</td>
<td>Overweight: 5</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
<td>15</td>
<td>21.4±0.68</td>
<td>Normal: 20</td>
</tr>
<tr>
<td>C</td>
<td>13</td>
<td>17</td>
<td>21.3±1.09</td>
<td>Underweight: 5</td>
</tr>
<tr>
<td>D</td>
<td>16</td>
<td>14</td>
<td>21.1±0.68</td>
<td></td>
</tr>
</tbody>
</table>

There were no statistically significant differences between the groups.

*Overweight: body mass index (BMI) ≥23; normal: 18.5–22.9; underweight: BMI ≤18.5.

### Table 2 Generalised mixed effect model analysis

<table>
<thead>
<tr>
<th>Group</th>
<th>Indices</th>
<th>Time 1</th>
<th>Time 2</th>
<th>Time 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>bpm</td>
<td>64.97±8.27</td>
<td>59.73±6.67</td>
<td>62.15±6.75</td>
</tr>
<tr>
<td>B</td>
<td>68.25±9.33</td>
<td>64.72±7.98*</td>
<td>66.20±8.03*</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>68.15±7.91</td>
<td>63.82±7.24*</td>
<td>65.95±7.100</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>61.80±7.69†</td>
<td>59.38±8.16†</td>
<td>60.50±8.50†</td>
<td></td>
</tr>
<tr>
<td>SDNN</td>
<td>A</td>
<td>79.80±34.58</td>
<td>87.60±33.90</td>
<td>92.80±37.35</td>
</tr>
<tr>
<td>B</td>
<td>64.68±30.91*</td>
<td>67.69±25.83*</td>
<td>68.15±29.91*</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>68.19±19.27</td>
<td>67.39±18.63*</td>
<td>70.07±21.09</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>66.29±29.55</td>
<td>64.45±25.68*</td>
<td>61.24±19.36*</td>
<td></td>
</tr>
<tr>
<td>RMSSD</td>
<td>A</td>
<td>32.60±53.16</td>
<td>23.23±23.72</td>
<td>17.25±17.07</td>
</tr>
<tr>
<td>B</td>
<td>45.85±64.5</td>
<td>23.18±22.22</td>
<td>17.37±14.92</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>35.67±56.59</td>
<td>22.88±20.85</td>
<td>19.90±17.29</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>30.38±26.52</td>
<td>27.27±28.95</td>
<td>22.80±38.10</td>
<td></td>
</tr>
<tr>
<td>Triangular index</td>
<td>A</td>
<td>16.67±5.20</td>
<td>17.20±4.37</td>
<td>17.57±5.43</td>
</tr>
<tr>
<td>B</td>
<td>14.07±5.00*</td>
<td>15.83±4.91</td>
<td>15.71±3.32</td>
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</tr>
<tr>
<td>C</td>
<td>15.8±4.04</td>
<td>15.77±3.83</td>
<td>16.13±4.77</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>14.73±5.67</td>
<td>14.17±4.67*</td>
<td>13.83±3.97*</td>
<td></td>
</tr>
<tr>
<td>lnVLF A</td>
<td>7.18±1.08</td>
<td>7.46±0.71</td>
<td>7.36±0.80</td>
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</tr>
<tr>
<td>B</td>
<td>6.49±0.90</td>
<td>6.96±0.39*</td>
<td>7.02±0.90</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>6.96±0.72</td>
<td>7.07±0.64</td>
<td>7.09±0.60</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>6.86±1.04</td>
<td>6.98±0.96*</td>
<td>6.67±0.91*</td>
<td></td>
</tr>
<tr>
<td>lnLF A</td>
<td>7.36±1.27</td>
<td>7.66±0.90</td>
<td>7.61±0.87</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>7.01±1.00</td>
<td>7.07±0.85*</td>
<td>7.08±1.02*</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>7.05±0.64</td>
<td>7.06±0.71*</td>
<td>7.20±0.86</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>6.82±1.11*</td>
<td>6.76±1.04*</td>
<td>6.72±0.97*</td>
<td></td>
</tr>
<tr>
<td>lnHF A</td>
<td>7.38±1.33</td>
<td>7.70±1.07</td>
<td>7.37±1.09</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>6.90±1.02</td>
<td>7.15±0.78*</td>
<td>7.10±0.83</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>7.01±0.76</td>
<td>7.09±0.49*</td>
<td>7.11±0.74</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>7.09±1.04</td>
<td>7.12±1.10*</td>
<td>7.05±1.14</td>
<td></td>
</tr>
<tr>
<td>LF/HF A</td>
<td>1.27±0.92</td>
<td>1.13±0.60</td>
<td>1.50±0.85</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>1.43±0.98</td>
<td>1.10±0.69</td>
<td>1.19±0.70</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>1.27±0.73</td>
<td>1.25±0.84</td>
<td>1.34±0.77</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>1.05±0.84</td>
<td>0.97±0.85</td>
<td>1.06±1.00</td>
<td></td>
</tr>
</tbody>
</table>

Group A, HT7 verum acupuncture group; group B, HT7 non-penetrating sham acupuncture group; group C, sham acupuncture point group; group D, no acupuncture group.

Time 1, 10 min before acupuncture; time 2, 10 min during acupuncture; time 3, 10 min after acupuncture.

*p<0.05 compared with group A.

**p<0.05 compared with group B.

†p<0.05 compared with group C.

bpm, beats/min; HF, high frequency; LF, low frequency; ln, natural log; RMSSD, root mean square of SD of normal-to-normal intervals; SDNN, SD of normal-to-normal intervals; SDANN, SD of all normal-to-normal intervals; VLF, very-low frequency.
However, this was contradicted by our finding that, compared with no acupuncture, bpm (HR) was not statistically reduced after verum acupuncture. Anderson et al\textsuperscript{3} proposed that acupuncture exerts its effects through physiological regulation including improvement of HRV, synchronisation of the two components of the ANS and a reduction in HR, which may occur secondary to sympathetic inhibition and/or parasympathetic activation. Compared with no acupuncture, SDNN, triangular index, VLF and HF were higher in the HT7 verum acupuncture group during acupuncture, which may indicate activation of the cardiac sympathetic system to maintain the cardiac output. There are data from Yao et al\textsuperscript{25} showing that acupuncture-like stimulation leads to an initial increase in HR/BP during stimulation followed by sustained cardiovascular depression in rats, suggesting that acupuncture stimulation initially activates the cardiac sympathetic system to maintain cardiac output. It is widely speculated that acupuncture stimulation has bidirectional effects on autonomic regulation, which may explain why HR did not decrease as anticipated. It is also possible that bpm (HR) may not have decreased as expected during the study period because of the immediate effects of acupuncture and the relatively short follow-up. Consequently we may have missed putative long-term autonomic effects in this acute experiment.

Additionally, the small study sample size, inclusion of only healthy volunteers and the single session with a single needle limit the interpretation of our results and may be responsible for these apparently anomalous findings.

In summary, this preliminary study suggests that acupuncture at HT7 could affect cardiac autonomic neural regulation in healthy subjects, mainly via the parasympathetic system, manifest as a reduction in HR and increased HRV.

Summary points

- We examined the effect of acupuncture at HT7 on heart rate variability (HRV) in 120 healthy volunteers compared with HT7 non-penetrating sham acupuncture, acupuncture at a sham point and no acupuncture.
- The HT7 verum acupuncture group had higher very-low frequency, low frequency and high frequency components of HRV compared with all controls during but not after acupuncture, and higher SD of normal-to-normal intervals (SDNN) compared with sham and no acupuncture.
- Acupuncture at HT7 affects cardiac autonomic neural regulation in healthy subjects, most likely via the parasympathetic system.


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Competing interests  None.

Patient consent  Obtained.

Ethics approval  The Ethics Committee of the TCM Department of First Military Medical School approved this study (http://www.chictr.org; Registration No ChiCTR-TRC-08000302).

Provenance and peer review  Not commissioned; externally peer reviewed.

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