Is there a difference between the effects of single and triple indirect moxibustion stimulations on skin temperature changes of the posterior trunk surface?

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ABSTRACT

Objectives: To determine whether any difference exists in responses to indirect moxibustion (IM) relative to thermal stimulation duration.

Methods: In experiment 1, 9 subjects attended two experimental sessions consisting of single stimulation with IM or triple stimulation with IM, using a crossover design. A K-type thermocouple temperature probe was fixed on the skin surface at the GV14 acupuncture point. IM stimulation was administered to the top of the probe in order to measure the temperature curve. In addition, each subject evaluated his or her subjective feeling of heat on a visual analogue scale after each stimulation. Experiment 2 was conducted on 42 participants, divided into three groups according to the envelope allocation method: single stimulation with IM (n=20), triple stimulation with IM (n=11) and a control group (n=11). A thermograph was used to obtain the skin temperature on the posterior trunk of the participant. To analyse skin temperature, four arbitrary frames (the scapular, interscapular, lumbar and vertebral regions) were made on the posterior trunk.

Result: In experiment 1, no significant difference in maximum temperature was found in IM and subjective feeling of heat intensity between single and triple stimulation with IM. In experiment 2, increases in skin temperature occurred on the posterior trunk, but no differences in skin temperature occurred between the groups receiving single and triple stimulation with IM.

Conclusion: No difference exists in the skin temperature response to moxibustion between the single and triple stimulation with IM.

INTRODUCTION

Moxibustion has been used in tandem with acupuncture to treat and prevent various illnesses in eastern Asia since ancient times. It is a thermal treatment that involves burning the herb moxa (Artemisia vulgaris, commonly called mugwort) over acupuncture points. The practice is generally divided into two procedural forms: direct moxibustion and indirect moxibustion (IM). Direct moxibustion involves burning the moxa directly on the skin. IM, on the other hand, provides thermal stimulation without direct contact between the burning moxa and the skin’s surface.

Thermal stimulation provides thermal energy to the skin surface and excites cutaneous mechanoreceptors. Adriaensen et al demonstrated that 44.5–46.5°C thermal stimulation applied to human skin activated A-fibre mechano-heat nociceptors (AMH). A study by Fitzgerald and Lynn indicated that administration of 50–55°C thermal stimulation to animals (cats, rabbits) activates high-threshold mechanoreceptors. Goto et al showed that 60–70°C thermal stimulation achieved by administering moxibustion to human skin activates C-fibre mechano-heat nociceptors (CMH). These previous studies showed that thermal stimulation over 44.5°C elicits excitation of receptors such as CMH and AMH.

Sato et al suggested that various somatosensory stimulations, such as mechanical stimulation (electrical stimulation), as well as thermal stimulation, increase muscle blood flow through the vasodilatation response. Further, a study by Agarwal-Kozlowski et al showed an increase in skin temperature during electroacupuncture stimulation. Studies by Balogun et al and Cramp et al, on the other hand, used transcutaneous electrical nerve stimulation and showed only an increase in blood flow volume without detecting any significant increase in local skin temperature. It has been suggested that local thermal stimulation induces blockage of the muscarinic receptor and production of prostaglandins as the mechanism of vasodilatation response. Noguchi et al reported the involvement of the sympathetic α receptor system as part of the mechanism for alterations of peripheral circulation by IM.

Given the various mechanisms of action of IM, the magnitude of thermal energy is greatly affected by temperature intensity and the size of the stimulated area and also by the duration of heat application. According to our knowledge, however, no previous studies have compared the responses of IM relative to the duration of thermal stimulation.
Although serious complications from acupuncture and moxibustion are considered rare, burns have been reported due to both direct and indirect forms of moxibustion. In Japan, practitioners have traditionally used a moxibustion method that involves moxibustion application multiple times on the same acupuncture point. However, multiple moxibustion stimulation in the same location may increase the risk of burns. Thus, we consider determining the optimal duration of thermal stimulation to be clinically important, both to optimise therapeutic benefits and to minimise the adverse events associated with moxibustion, including burns.

The purpose of this study was to test whether the single moxibustion application method provides sufficient skin temperature elevation in a localised region in comparison with the multiple moxibustion application method. We examined the differences in skin temperature response with two different durations of stimulation on the same sites.

Two experiments (experiment 1 and 2) were conducted. In experiment 1, we compared the maximum temperatures on the temperature curves resulting from 3 min and 9 min stimulation via IM. In experiment 2, we compared the skin temperature changes of the posterior trunk surface resulting from 3 and 9 min stimulations via IM with the non-stimulated control group.

**METHODS**

**Subjects**

The participants were 51 healthy men (nine for experiment 1, 42 for experiment 2), recruited from students and staff members of the Tsukuba University of Technology; the subjects had a mean age of 24.6±6.1 years.

All participants were informed of the purpose and nature of the experiments; then written consent was obtained from each participant, in compliance with the World Medical Association Declaration of Helsinki. The study was approved by the research ethics committee of the Tsukuba University of Technology.

For each study, participants were asked to remove clothing from their upper bodies, lie on a table in a prone position and then rest for 10 min.

**Interventions**

In both experiments 1 and 2, the stimulation site was GV14 (between the C7 and T1 spinous process). The GV14 acupuncture point has been used for neck and shoulder pain conditions in clinical and research settings. We consider the GV14 point suitable when attempting to observe skin temperature response on thermography.

Thermal stimulation was applied by IM (Kamaya Mini; Kamaya Moxa, Tokyo, Japan). Kamaya Mini IM consists of a cylindrical paper pipe (9 mm in diameter and 12 mm in height) filled with moxa. There is an 8 mm cavity between the moxa and the skin’s surface, permitting the indirect administration of thermal stimulation (figure 1).

The thermal heat emitted by a single application of Kamaya Mini IM lasts approximately 5 min. Two different time durations were used for comparison: 3 min of stimulation (moxibustion applied once—hereafter referred to as ‘single stimulation with IM’) and 9 min of stimulation (moxibustion applied three times—hereafter referred to as ‘triple stimulation with IM’). For triple stimulation with IM, the burned moxa was immediately replaced by the new one, thus there was virtually no time interval between the applications of moxa.

**Experiment 1**

Experiment 1 was conducted using a crossover design. All subjects attended two experimental sessions conducted on different days. During the experimental sessions, IM was applied with 3 min of stimulation or 9 min of stimulation. Nine subjects (mean age 29.3±4.6) were randomly assigned to two groups by the envelope allocation method. One group (n=5) received a single stimulation with IM in the first experimental session and then received three stimulations with IM in the second session. Another group (n=4) completed the sessions in a reversed sequence. One week separated the first and second experimental sessions.

**Experiment 2**

Experiment 2 was conducted on 42 participants, randomly divided into three groups according to the envelope allocation method: 20 participants (mean age 23.5±3.9) were assigned to the single stimulation with IM group, 11 participants (mean age 21.5±3.9) were assigned to the triple stimulation with IM group and 11 participants (mean age 26.0±9.4) were in the control group (no application of IM).

**Measurement**

**Experiment 1**

A thermocouple data logger (TC-08; Pico Technology, Cambridgeshire, UK) and a K-type thermocouple temperature probe (ANBE SMT, Yokohama, Japan) were used to...
measure the temperature curves of IM. The tip of the probe (0.2 mm diameter) was in direct contact with skin surface, and IM was placed on top of the sensory probe. Figure 1 illustrates the experimental setup.

The temperature of IM was measured every 0.1 s, and the data were acquired via specialised software (Pico Log Recorder) on the Windows XP operating system.

Under ambient room conditions of 24.5±0.9°C and 49.3±2.7% humidity, the K-type thermocouple temperature probe was fixed on the skin surface at the GV14 acupuncture point with Kapton tape. IM stimulation was administered on the top of the probe in order to measure the temperature curve.

Each subject evaluated his or her subjective feeling of heat on a visual analogue scale (VAS) immediately after each stimulation.

Experiment 2
A thermograph (JTG-5310; JEOL, Tokyo, Japan) was used to obtain the skin temperature on the posterior trunks of the participants. Thermographic images were then obtained at the following time periods: before and immediately after the administration of IM, and 5, 10, 15 and 20 min afterwards.

The following locations were marked in order to develop arbitrary frames: the spinous process of the Th1, Th3, Th7, Th11 and L4; the medial border of the scapular spines (bilateral); the inferior border of the scapulas (bilateral); and the posterior superior iliac spine (bilateral).

To analyse skin temperature, four arbitrary frames (the scapular, interscapular, lumbar and vertebral regions) were made on the posterior trunk. The average temperatures of those frames were then obtained (figure 2).

Statistics
For experiment 1, the subjective feelings of the heat intensity of IM indicated on the VAS after single and triple stimulation with IM were compared using the Mann–Whitney U test.

The maximum temperature during each stimulation period (in the single stimulation with IM session and the first, second and third stimulations in the triple stimulation with IM session) was analysed via Bonferroni’s multiple comparison tests. The time to reach maximum temperature was also analysed via Bonferroni’s multiple comparison tests.

For experiment 2, Sidak’s multiple comparison test was used to test the age factor among the three groups. Serial changes in skin temperature between the groups (groups receiving single and triple stimulation with IM and the control group) were analysed by mixed-model two-way analysis of variance and linear analysis using Sidak’s multiple comparison test. Serial changes in skin temperature within the groups were analysed by the mixed-model one-way analysis of variance and Bonferroni’s multiple comparison tests.

SPSS advanced models version 15 was used as the statistical analysis software. In all tests, the level of significance was set at p<0.05.

RESULTS
Experiment 1
For subjective feelings of heat intensity during IM, there was no significant difference between single (VAS 37.0±36.1 mm) and triple stimulation with IM (VAS 55.8±37.3 mm) (p=0.121).

For the maximum temperature in IM, there was also no significant difference between the single stimulation with IM (51.59±5.94°C) and the first (50.04±3.54°C), second (50.37±3.69°C) and third (53.76±7.29°C) stimulations during the triple stimulation with IM session.

Time to maximum temperature was 170.29±8.22 s in the single stimulation with IM session (figure 3). For the triple stimulation with IM session, the time was 176.01±5.06 s in the first, 173.46±9.53 s in the second and 169.53±9.14 s in the third stimulations (figure 3). There was no significant difference between the single and triple stimulation with IM sessions.
Experiment 2
There was no difference in age among the three groups.

Skin temperature changes in the posterior trunk

Changes in skin temperature in the general upper back

▶ Skin temperature responses before and after moxibustion applications are summarised in figure 4A and table 1.
▶ In the group receiving single stimulation with IM, the skin temperature increased from 34.32±0.66°C at the baseline to 34.65±0.57°C (p=0.00) 20 min after moxibustion administration.
▶ In the group receiving triple stimulation with IM, the skin temperature increased from 34.40±0.57°C at the baseline to 34.70±0.57°C (p=0.00) 20 min after moxibustion.
▶ In the control group, there were no significant changes compared with baseline.
▶ There was no significant difference in skin temperature responses between the groups.

Skin temperature changes in the interscapular region

▶ Skin temperature responses before and after moxibustion applications are summarised in figure 4B and table 1.
▶ In the group receiving single stimulation with IM, the skin temperature increased from 34.38±0.72°C at the baseline to 34.74±0.64°C (p=0.00) 20 min after moxibustion.
▶ In the group receiving triple stimulation with IM, the skin temperature increased from 34.52±0.58°C at the baseline to 34.78±0.59°C (p=0.00) 20 min after moxibustion.
▶ In the control group, there were no significant changes compared with baseline.
▶ There was no significant difference in skin temperature responses between the groups.

Figure 3  The temperature curve in 3 and 9 min administrations of IM. (A) Solid line: IM stimulation for 3 min (single stimulation with IM) (green line). (B) Dotted line: IM stimulation for 9 min (triple stimulation with IM). B1 (red line): first 3 min stimulation. B2 (blue line): second 3 min stimulation. B3 (yellow line): third 3 min stimulation. IM, indirect moxibustion.

Figure 4  Skin temperature changes in the group receiving single stimulation with indirect moxibustion (IM), group receiving triple stimulation with IM and the control group. Skin temperature changes in the (A) scapular region; (B) interscapular region; (C) lumbar region; (D) vertebral region. Group receiving single stimulation with IM (pink), group receiving triple stimulation with IM (yellow) and the control group (green).
Skin temperature changes in the lumbar region

- Skin temperature responses before and after moxibustion applications are summarised in figure 4C and table 1.
- In the group receiving single stimulation with IM, the skin temperature increased from 34.14±0.64°C at the baseline to 34.79±0.40°C (p=0.00) 20 min after moxibustion.
- In the group receiving triple stimulation with IM, the skin temperature increased from 34.26±0.49°C at the baseline to 34.79±0.40°C (p=0.00) 20 min after moxibustion.
- In the control group, there were no significant changes compared with baseline.
- There was no significant difference in skin temperature responses between the groups.

Skin temperature changes in the spinal region

- Skin temperature responses before and after moxibustion applications are summarised in figure 4D and table 1.
- In the group receiving single stimulation with IM, the skin temperature increased from 34.40±0.65°C to 34.94±0.55°C (p=0.00) 20 min after moxibustion.
- In the group receiving triple stimulation with IM, the skin temperature increased from 34.46±0.54°C to 34.86±0.52°C (p=0.00) 20 min after moxibustion.
- In the control group, there were no significant changes compared with baseline.
- There was no significant difference in skin temperature responses between the groups.

DISCUSSION

A study by Chiba et al indicated that IM (Kamaya Mini—mild heat type) resulted in maximum skin surface temperatures of 65°C and 45°C in the subcutaneous tissue of rats. In our study, the skin surface temperature during IM ranged from 46 to 67.5°C (mean temperature 50°C). The slight difference in heat temperatures between the studies are probably related to the difference between the basal skin temperatures of humans and rats.

More recently, the thermal properties of IM have been investigated in a laboratory setting. The form of IM used in that study, however, was different from the IM used in this study. In that study, moxa was placed on sliced garlic, which acted as an insulator between the burning moxa and a thermocouple used for the measurements. The study showed that the maximum temperature with moxibustion applied on a 1.7 mm garlic slice reached 43°C at the first application, then eventually rose to 55°C during the fourth consecutive application. This result contrasts with our study, which showed no difference in temperature between single and triple applications of IM. It should be noted that in the previous study the same garlic slice was used during repeated moxa applications. The contradictory results, therefore, are probably due to the retained accumulated heat in the garlic slice.

Nevertheless, the IM stimulation used in both the present and previous studies can be considered thermal stimuli that excite mechano-heat-sensitive nociceptors such as AMH and CMH.

Sato et al indicated that a response in neuroeffectors occurs through different mechanisms, including central sensitisation, peripheral sensitisation and the axon reflex; and that those response mechanisms are evoked by mechanical, chemical or thermal stimulations. Sato et al further indicated, however, that skin nociceptors have high thresholds against mechanical, thermal or chemical stimulation; thus, it is hard to excite these receptors without activating low-threshold sensory receptors. Moreover, the nociceptors of primates and humans are most responsive to thermal heat stimuli. Thermal stimulation is...
considered to simultaneously activate the Aδ fibres (III group) that insert in the epidermis and afferent fibres and nociceptive C (IV group) afferent fibres without activating other sensory receptors.

As indicated, the thermal heat administered in this study reached approximately 50°C; thus, the responses seen in this study are thought to occur via the skin nociceptors. The excitation of skin nociceptors then influences the skin's peripheral vessels, resulting in reactions such as an increase in blood flow and a rise in skin temperature. Ka\u00b4wakita et al\u00b416 indicated that the axon reflex induced by somatosensory stimulation such as acupuncture or moxibustion is related to the activation of the polymodal receptor. Noguchi et al\u00b410 observed blood flow change in the hind limbs of rats due to moxibustion stimulation. The result showed that moxibustion stimulation resulted in vasodilatation, possibly via the excitation of the α-adrenergic receptor.

We hypothesise that the increase in skin temperature through IM seen in this study was elicited by the excitation of the thermal nociceptors via the autonomic nervous system. In this study, an increase in the skin temperature of the posterior trunk was seen after the application of IM in either 3 or 9 min stimulations.

Our study confirmed that a sufficient skin temperature increase could be achieved with a single application of moxibustion. It should be noted, however, that the skin temperature after 20 min appeared to be the same for single and triple stimulation with IM—an intriguing finding worth exploring further in relation to possible efficacy and burn risk.

There are limitations to this study. Based on our post hoc power analysis, the sample sizes were insufficient for both experiments 1 and 2, indicating possible type II errors. Further studies using larger samples are needed to confirm our findings. In addition, possible sensory responses and psychological influences derived from placing the moxibustion tube directly on the skin cannot be ignored completely. For experiment 2, we used ‘rest’ as the control; however, it might be advisable in future trials to use sham IM in order to provide similar tactile sensations among groups.17 18 Further study needs to be conducted in order to determine a possible difference among the skin temperature responses elicited by administering IM on different acupuncture points.

In conclusion, no differences manifested in the temperature curves and maximum temperatures with the use of two different durations of IM. The sensory heat intensity was also not affected by the different duration of stimulation. Increases in skin temperature occurred on the posterior trunk, but no differences in the response of skin temperature occurred between the groups receiving single and triple stimulation with IM.

Competing interests None.

Ethics approval This study was conducted with the approval of the research ethics committee of the Tsukuba University of Technology.

Provenance and peer review Not commissioned; externally peer reviewed.

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_Acupunct Med_ 2011 29: 116-121 originally published online March 13, 2011
doi: 10.1136/aim.2010.002741

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