Effect on Pupil Diameter of Shiatsu Stimulation to the Abdominal Region

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I. Introduction

The Japan Shiatsu College has previously conducted research into the effects of shiatsu stimulation on various physiological functions, reporting in issues 22–24 of the Journal of the Japan College Association of Oriental Medicine on the effect of shiatsu stimulation to the abdominal region in reducing heart rate[1] and blood pressure[2] and increasing peripheral muscle blood volume[3], and in issue 31on its stimulation of gastrointestinal motility[4].

It has been reported that the effect of somatosensory stimulation on organ effectors differs with respect to mechanism and response depending on the organ or body involved[5]. Therefore it is necessary to investigate the response to shiatsu stimulation for each organ effector.

In this report, we study a function not researched in previous reports, using an electronic pupillometer to measure pupillary reaction as a means of evaluating autonomic nervous function.

II. Methods

1. Subjects

Research was conducted on 29 healthy adult students of the Japan Shiatsu College (17 male, 12 female), with an average age of 39.8 ± 13.1 years old. Test procedures were fully explained to each test subject and their prior consent obtained.

2. Test period and location

Testing was conducted in the basic medicine research lab at the Japan Shiatsu College between April 17 and July 24, 2010. Room temperature was 25.0 ± 2.0°C and humidity was 65 ± 12.0%. Illumination was 100 lux.

3. Measurement procedures

Pupil diameter was measured using a binocular electronic pupillometer (Newopto Corp. ET-200) (Fig. 1).

4. Stimulation

(1) Area of stimulation (Fig. 2)

With the test subject in the supine position, stimulation was applied using two-thumb pressure to the 20 points of the abdominal region, as per basic Namikoshi shiatsu.

(2) Duration and method of stimulation

Pressure was applied to the 20 points of the abdominal region, 3 seconds per point, repeated for 3 minutes

Fig. 1. Binocular electronic pupillometer

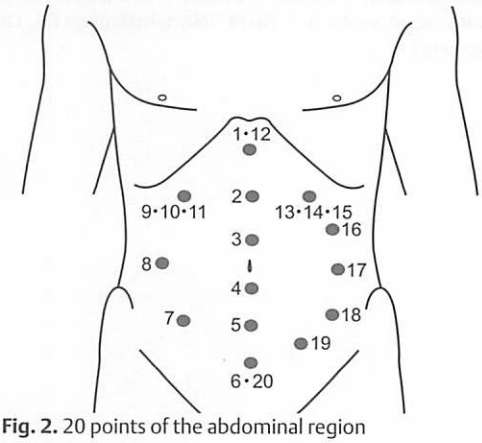

Fig. 2. 20 points of the abdominal region

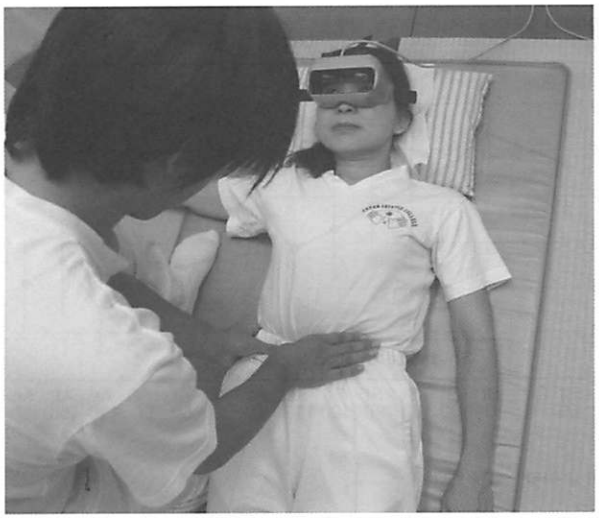

Fig. 3. Measurement using pupillometer

duration. Stimulation was applied using standard pressure (pressure gradually increased, sustained, and gradually decreased), and the amount of pressure used in stimulation was classified as standard (pressure regulated so as to be pleasurable for the test subject).

5. Test procedure

Test procedures were fully explained to each test subject and their prior consent obtained. They were also questioned on physical condition and history of eye disease. Two tests were performed, one in which shiatsu stimulation was applied (hereafter, the stimulation group) and one in which no shiatsu stimulation was applied (hereafter, the non-stimulation group). Both interventions were carried out on all 29 test subjects on different days.

For measurement using the electronic pupillometer, test subjects laid in the supine position, fixing their gaze during testing on a 1.5 cm diameter mark affixed to the ceiling 250 cm above the floor (Fig. 3).

(1) Stimulation group

In the supine position, test subjects rested for 3 minutes with their eyes open, then received 3 minutes of shiatsu stimulation to the abdominal region. They rested for another 3 minutes post-stimulation. Pupil diameter was measured for 9 minutes in total. (Fig. 4)

(2) Non-stimulation group

For the non-stimulation group, test subjects rested in the supine position instead of receiving shiatsu. All other procedures were the same as for the stimulation group.

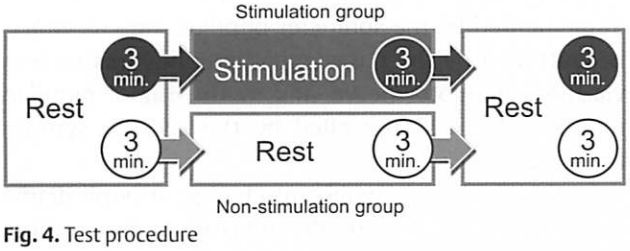

Fig. 4. Test procedure

6. Data analysis

Of the 3 minutes of pre-stimulation rest, 3 minutes stimulation, and 3 minutes post-stimulation, the measurement taken 60 seconds prior to stimulation (Bf.) was established as the control value, with average values during stimulation (St.) and post-stimulation (Af.) calculated at 30 second intervals.

7. Statistical processing

In analysis of inter-group pre/post-stimulation data between the non-stimulation and stimulation groups, pupil diameter measurement values were analyzed using Bonferroni multiple comparison using a general linear model. Chronological inter-group differences between the non-stimulation and stimulation groups were analyzed using Bonferroni multiple comparison and two-way analysis of variance. A significance level of <5% was determined to be significant.

III. Results

On the right side, an interaction effect was displayed between chronological changes to pupil diameter ($p=0.044$) (Fig. 5).

In the stimulation group, a gradual trend to contraction was displayed during the 3 minutes rest in the supine position pre-stimulation, with dilation occurring immediately at commencement of stimulation, dilating to (St.0) 5.376 ± 0.205 (mean ± SE) from the control value of 5.226 ± 0.222, followed by a gradual trend to contraction during stimulation, contracting to 4.874 ± 0.227 at St.150. Immediately post-stimulation (Af.0), dilation once again occurred to 4.997 ± 0.208, but then a gradual trend to contraction was displayed, with a diameter at 60 seconds post-stimulation (Af.60) of 4.750 ± 0.213 and maximum contraction of 4.710 ± 0.215 occurring at 90 seconds post shiatsu stimulation (Af.90). Contraction continued until 150 seconds post-stimulation (Af.150).

A significant difference in contraction of the stimulation group's right-side pupil diameter was confirmed using multiple comparisons in which pre-stimulation values were compared to 60 seconds post-stimulation (Af.60) ($p=0.038$) and 90 seconds post-stimulation (Af.90) ($p=0.009$).

In the non-stimulation group, a gradual trend to contraction was displayed starting 60 seconds pre-stimulation (Bf.), when diameter was 5.138 ± 0.203, with maximum contraction of 4.812 ± 0.186 occurring immediately post-stimulation (Af.0). Multiple comparisons with pre-stimulation values indicated no significant change in right-side pupil diameter for the

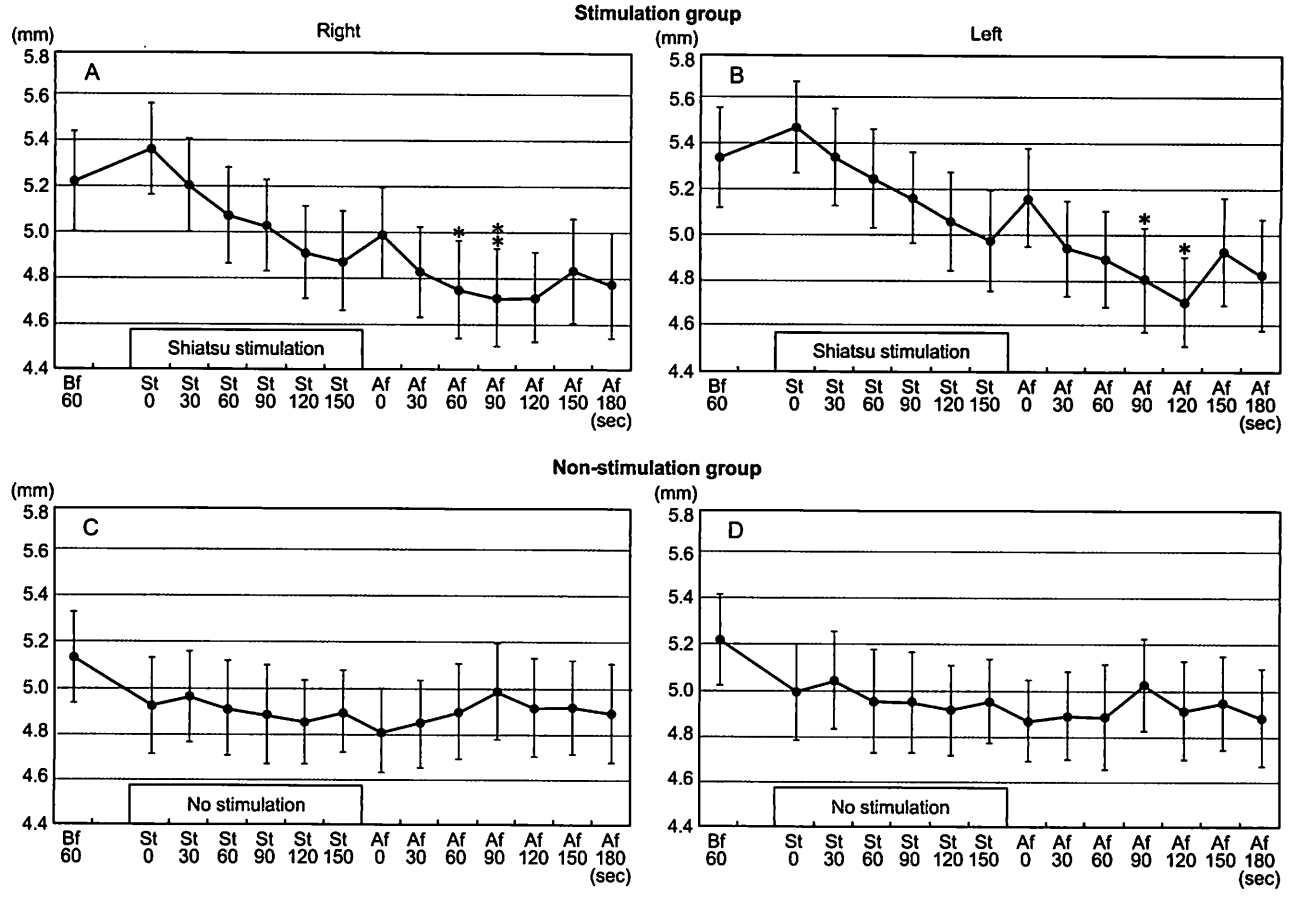

Fig. 5. Changes to pupil diameter due to shiatsu stimulation of the abdominal region
A: right pupil (stimulation group); B: left pupil (stimulation group); C: right pupil (non-stimulation group); D: left pupil (non-stimulation group). On each graph, the vertical axis represents pupil diameter (mm) and the horizontal axis represents elapsed time (sec), with mean ± SE displayed. Bf: pre-stimulation (control); St: during stimulation; Af: post-stimulation; *: $p<0.05$; **: $p<0.01$

non-stimulation group.

On the left side, no interaction effect was displayed in chronological changes to pupil diameter ($p=0.064$) (Fig. 5).

In the stimulation group, a gradual trend to contraction was displayed during the 3 minutes rest in the supine position pre-stimulation, with dilation occurring immediately at commencement of stimulation, dilating to (St.0) 5.488 ± 0.205 (mean ± SE) from the 60-second pre-stimulation value (Bf.) of 5.352 ± 0.225, followed by a gradual trend to contraction during stimulation, contracting to 4.981 ± 0.224 at 150 seconds after commencement of stimulation (St.150). Immediately post-stimulation (Af.0), dilation once again occurred to 5.178 ± 0.210, but then a gradual trend to contraction was displayed, with a diameter at 90 seconds post-stimulation (Af.90) of 4.812 ± 0.229 and maximum contraction of 4.717 ± 0.201 occurring at 120 seconds post shiatsu stimulation (Af.120). Contraction continued until 150 seconds post-stimulation (Af.150).

A significant difference in contraction of the stimulation group's left-side pupil diameter was confirmed using multiple comparisons in which pre-stimulation values were compared to 90 seconds post-stimulation (Af.90) ($p=0.029$) and 120 seconds post-stimulation (Af.120) ($p=0.021$).

In the non-stimulation group, a gradual trend to contraction was displayed starting 60 seconds pre-stimulation (Bf.) when diameter was 5.233 ± 0.203, with maximum contraction of 4.870 ± 0.185 occurring immediately post-stimulation (Af.0). Multiple comparisons with pre-stimulation values indicated no significant change in left-side pupil diameter for the non-stimulation group.

IV. Discussion

It is recognized that regulation of pupil diameter is implemented by the sphincter pupillae muscle, which is controlled by the parasympathetic nervous system via the oculomotor nerve, and by the dilator pupillae muscle, which is controlled by the cervical sympathetic nerves.

In this study, no significant change in pupil diameter was ascertained in the non-stimulation group,

whereas in the group that received shiatsu stimulation of the abdominal region, significant contraction of pupil diameter occurred.

Possible explanations of the autonomic mechanism for this response are: [1] activity was accentuated in the parasympathetic branch of the oculomotor nerve that controls the sphincter pupillae, causing the sphincter pupillae to contract; [2] activity was suppressed in the cervical sympathetic nerves that control the dilator pupillae, causing the dilator pupillae to relax; or [3] both [1] and [2] above were influential.

We have previously reported that heart rate is reduced due to shiatsu stimulation, and that this is probably due to an autonomic nervous system response involving either accentuation of heart parasympathetic nervous activity, suppression of heart sympathetic nervous activity, or a combination of the two[1]. In this study, pupillary reaction exhibited the same tendency.

It has been reported that generally in humans and animals pupil dilation occurs in response to pain stimulation[6]. We may assume that a dilation response did not occur in this study because subjects received standard shiatsu stimulation unaccompanied by pain.

It has been reported that, in anesthetized rats, a dilation response occurs in response to manual pressure stimulation[7] and electro-acupuncture stimulation[8] under light-adapted conditions. On the other hand, it has been reported that in healthy human subjects a contraction response occurs in response to acupuncture stimulation in dark-adapted conditions[9-11]. In addition to differences in test conditions such as presence or absence of anesthesia and species differences between humans and rats, differences in pupillary reaction due to non-nociceptive somatosensory stimulation such as acupuncture and manual pressure stimulation may arise depending on illumination volume.

V. Conclusions

From this study performed on healthy adults, the following is evident:

1. Shiatsu stimulation of the abdominal region resulted in significant contraction of pupil diameter.
2. A difference was observed compared to the non-stimulation group.

In closing, we would like to express our appreciation to the instructors and students of the Japan Shiatsu College who participated in this research.

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