Effect on Pupil Diameter of Shiatsu Stimulation to the Anterior Cervical and Lateral Crural Regions

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I. Introduction

The Japan Shiatsu College has previously reported in issues 22–34 of the Journal of the Japan College Association of Oriental Medicine on the effect of shiatsu stimulation on the circulatory system[1-4] (reduction in heart rate and blood pressure, increase in peripheral muscle blood volume, and increased skin temperature) and the alimentary system[4-6] (stimulation of gastrointestinal motility).

Last year[7], we began investigating the effect of shiatsu stimulation on pupil diameter using an electronic pupillometer, initially investigating the effect of shiatsu stimulation to the abdominal region. From this study, it was evident that pupil diameter contracted significantly as a result of shiatsu stimulation to the abdominal region. Building on those results, this year we will study the effect on pupil diameter of shiatsu stimulation to the anterior cervical and lateral crural regions, in order to investigate the different effect of shiatsu stimulation on pupil diameter depending on the area treated.

II. Methods

1. Subjects

Research was conducted on 21 students and instructors at the Japan Shiatsu College, 14 male and 7 female (19–48 years old; average age: 33.1 ± 9.6 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 23 and July 9, 2011. Room temperature was 22 ± 2.0°C and humidity was 79 ± 15.0%. Illumination was 100 lux.

3. Measurement procedures

Changes in pupil diameter were measured using a binocular electronic pupillometer (Newopto Corp. ET-200, Fig. 1), with the test subject in the supine position.

4. Stimulation

(1) Areas of stimulation (Figs. 2, 3)

With the test subject in the supine position, stimulation was applied using thumb-on-thumb pressure to the 6 points of the lateral crural region and one-handed thumb pressure to the 4 points of the anterior

Fig. 1. Binocular electronic pupillometer

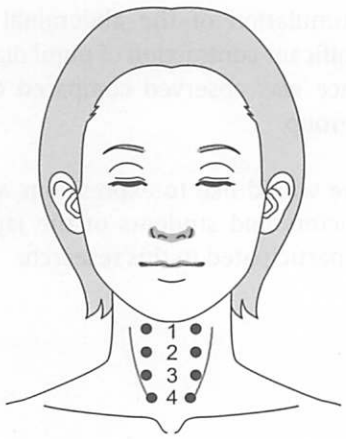

Fig. 2. 4 points of the anterior cervical region

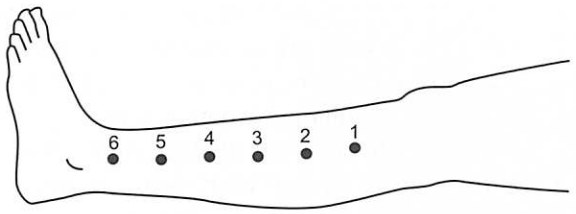

Fig. 3. 6 points of the lateral crural region

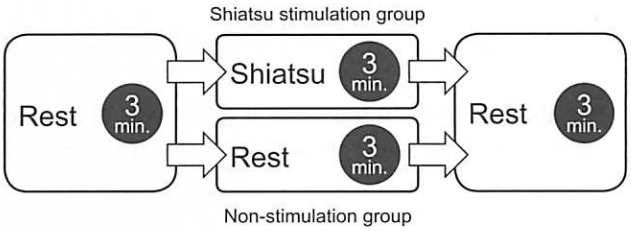

Fig. 5. Test procedure

cervical region, as per basic Namikoshi shiatsu.

(2) Method of stimulation

Stimulation consisted of pressure applications of 3 seconds per point, repeated for 3 minutes duration. Stimulation was applied using standard pressure (pressure gradually increased, sustained, and gradually decreased), regulated so as to be pleasurable for the test subject.

5. Test procedure (Figs. 4, 5)

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. Three tests were performed, one in which shiatsu stimulation was applied to the anterior cervical region (hereafter, the anterior cervical region stimulation group), one in which shiatsu stimulation was applied to the lateral crural region (hereafter, the lateral crural region stimulation group), and one in which shiatsu stimulation was not applied (hereafter, the non-stimulation group). The three interventions were carried out on all 21 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.

(1) Anterior cervical region 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 anterior cervical region. They then rested for another 3 minutes post-stimulation. Pupil diameter was measured for 9 minutes in total.

(2) Lateral crural region stimulation group

Procedure was the same as that for the anterior cervical region stimulation group, with stimulation carried out on the lateral crural region.

(3) Non-stimulation group

The non-stimulation group rested in the supine position for 9 minutes.

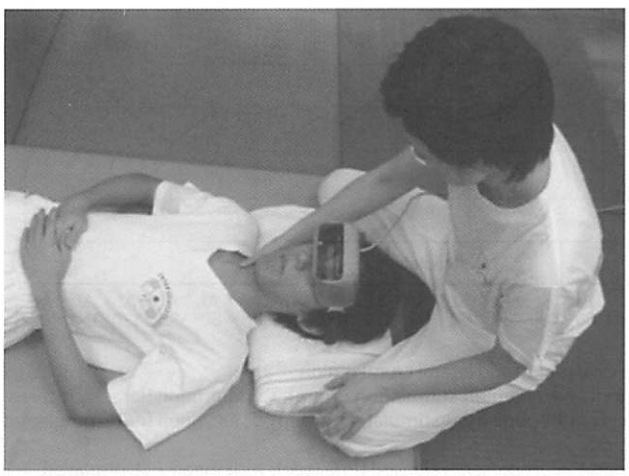

Fig. 4. Measurement using pupillometer

6. Data analysis

Taking pupil diameter 60 seconds prior to stimulation (Bf.60) as the control, data was analyzed for 5 seconds at 30-second intervals during stimulation (St.) and between 30 seconds (Af.) and 180 seconds post-stimulation (Af.).

7. Statistical processing

Pupil diameter measurement values were analyzed using Bonferroni multiple comparison and mixed model 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 ($p=0.05$).

Of the three groups, pupil diameter was larger in the non-stimulation group, both compared to the anterior cervical region stimulation group ($p=0.00$) and the lateral crural region stimulation group ($p=0.00$).

Compared to the control (Bf.60), pupil contraction occurred at 150 seconds after commencement of stimulation (St.150) ($p=0.037$), 90 seconds post-stimulation (Af.90) ($p=0.001$), and 120 seconds post-stimulation (Af.120) ($p=0.042$).

With stimulation of the anterior cervical region, compared to the control (Bf.60) significant pupil contraction occurred at 30 seconds (Af.30) ($p=0.002$), 60 seconds (Af.60) ($p=0.004$), 90 seconds (Af.90) ($p=0.00$), 120 seconds (Af.120) ($p=0.001$), 150 seconds (Af.150) ($p=0.00$), and 180 seconds (Af.180) post-stimulation.

With stimulation of the lateral crural region, there

was no change compared to the control (Bf.60).

With no stimulation, there was no change compared to the control (Bf.60).

On the left side, an interaction effect was displayed between chronological changes to pupil diameter (p=0.033).

Of the three groups, pupil diameter was larger in the non-stimulation group, both compared to the anterior cervical region stimulation group (p=0.00) and the lateral crural region stimulation group (p=0.00).

Compared to the control (Bf.60), pupil contraction occurred at 150 seconds after commencement of

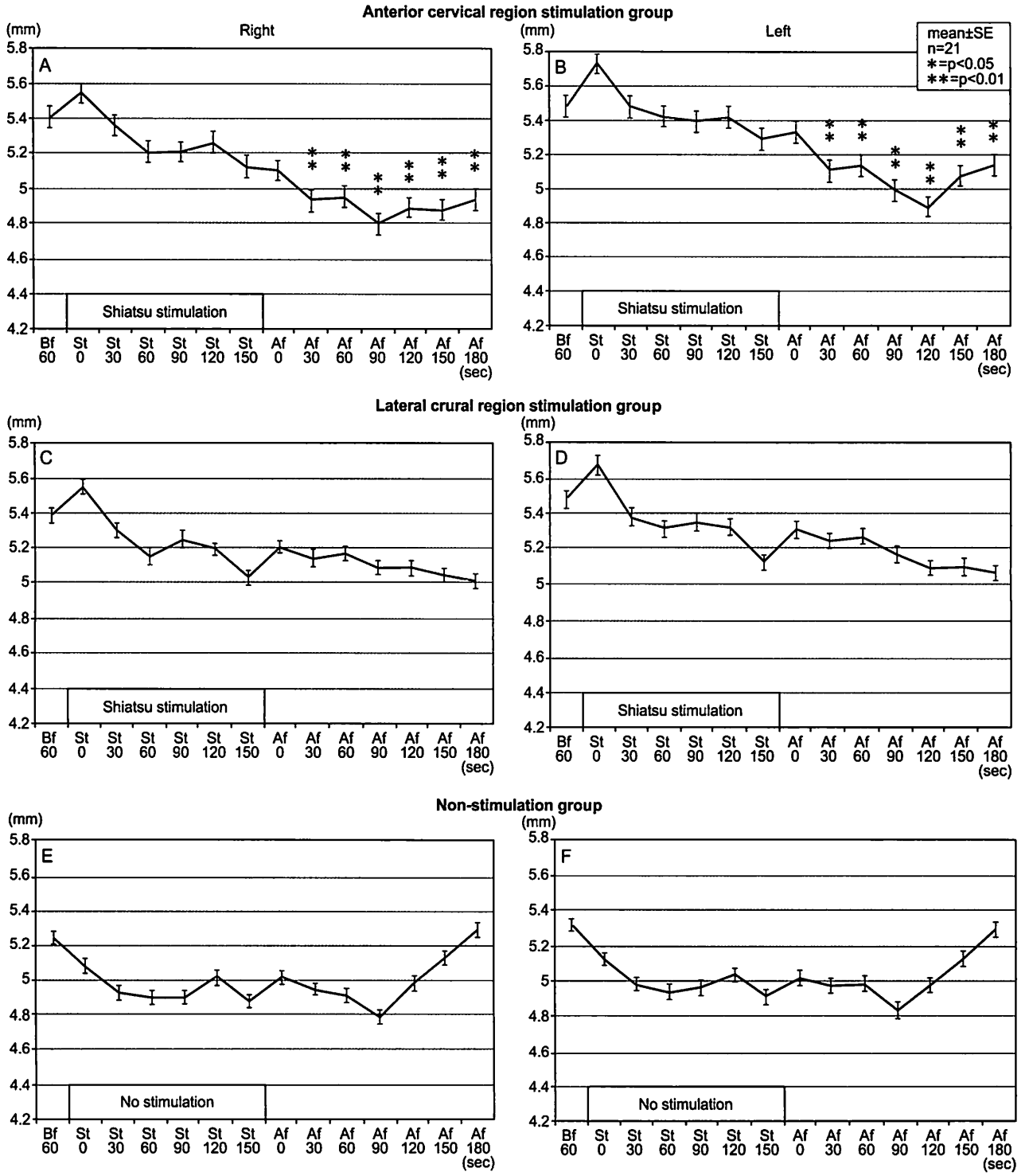

Fig. 6. Changes to pupil diameter due to shiatsu stimulation of the anterior cervical region and lateral crural region
A: right pupil (anterior cervical region stimulation group); B: left pupil (anterior cervical region stimulation group); C: right pupil (lateral crural region stimulation group); D: left pupil (lateral crural region stimulation group) ; E: right pupil (non-stimulation group); F: 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

stimulation (St.150) (p=0.048), 90 seconds post-stimulation (Af.90) (p=0.001), and 120 seconds post-stimulation (Af.120) (p=0.001).

With stimulation of the anterior cervical region, compared to the control (Bf.60) significant pupil contraction occurred at 30 seconds (Af.30) (p=0.004), 60 seconds (Af.60) (p=0.012), 90 seconds (Af.90) (p=0.00), 120 seconds (Af.120) (p=0.00), 150 seconds (Af.150) (p=0.001), and 180 seconds (Af.180) (p=0.012) post-stimulation.

With stimulation of the lateral crural region, no significant reaction in pupil diameter was ascertained.

With no stimulation, no significant difference was ascertained.

IV. Discussion

In this study, no significant change in pupil diameter was ascertained in the non-stimulation group or the group receiving shiatsu stimulation to the lateral crural region, but significant contraction of pupil diameter did occur in the group receiving shiatsu stimulation to the anterior cervical region.

It has been reported that pupil dilation occurs in response to pain stimulation[8], however we may assume that a dilation response did not occur in this study because subjects received standard shiatsu stimulation unaccompanied by pain.

Pupil diameter is regulated by the dilator pupillae muscle, which is controlled by the sympathetic nervous system (cervical sympathetic nerves), and by the sphincter pupillae muscle, which is controlled by the parasympathetic nervous system (oculomotor nerve). The pupil contraction response due to shiatsu stimulation observed in this study may have occurred as a result of either excitation of the parasympathetic nervous system, which controls the sphincter pupillae, suppression of sympathetic nervous system, which controls the dilator pupillae, or a combination of the two.

It has been indicated in the past that the sympathetic nervous system is involved in pupillary responses involving the higher brain centers[9, 10], but Ohsawa et al[11] and Shimura et al[12] showed that reflexive pupil dilation occurs in anesthetized rats due to electro-acupuncture and pinch stimulation, and is unaffected by severing of the cervical sympathetic nerves, confirming that dilation occurs due to suppression of the parasympathetic nervous system. They also reported on the important role the parasympathetic nervous system plays in the pupillary response in reaction to somatosensory stimulation. Due to such factors as species differences, the influence of anesthetic, and differences in light and dark adaptation, further study is required in the future.

The pupil contraction response due to shiatsu stimulation of the anterior cervical region may possibly have occurred via a pressoreceptor reflex, as the carotid sinus, which contains a pressoreceptor, is stimulated. Furthermore, the response may have been easy to elicit as the output level for the autonomic efferent pathway controlling the pupil and the area subject to shiatsu stimulation are in relatively close proximity.

Further basic research is required into the mechanisms and particulars of the subconscious effect of somatosensory stimulation on pupil diameter in humans. In the future, we hope to study the effect on pupil diameter of shiatsu stimulation to other areas of the body, and to clarify the effect or shiatsu stimulation on the autonomic nervous system.

V. Conclusions

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

1. Shiatsu stimulation of the anterior cervical region resulted in significant contraction of pupil diameter.
2. With shiatsu stimulation to the lateral crural region, significant response in pupil diameter could not be ascertained.

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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