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The Effect of Acupuncture on Muscle Blood Volume and Oxygenation

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1. Introduction

A considerable number of patients (61.5/1000) who complain of shoulder stiffness visit oriental therapeutic clinics (Journal of Health and Welfare Statistics, 2007). Several studies have shown that acupuncture can be a useful modality for treating pain due to muscle spasms (Lundeberg et al., 1988; Sandberg et al., 2005; Inoue et al., 2006). It is believed that shoulder stiffness is caused primarily by restriction of blood flow to the working muscles where accumulated metabolites appear to activate sympathetic vasoconstrictors. Acupuncture stimulation (AS) is reported to increase local tissue blood flow in animals (Noguchi et al., 1999; Sato et al., 2000; Uchida et al., 2007) and humans (Sakai 2005; Sandberg et al., 2003; Sandberg et al., 2005) and are applicable in therapeutic interventions of shoulder stiffness.

The effects of acupuncture include neural, endocrinological, cardiovascular, and immunological functions. Among cardiovascular effects, in particular, acupuncture stimulation elicits enhanced muscle blood flow via peripheral vasodilatation. The enhanced blood flow response induced by acupuncture may be attributable to C-fibre mediated axon reflex (Nishijo et al., 1997) resulting from noxious mechanical stimulation. Conventional invasive techniques for evaluating muscle blood flow have limitations such as a relatively great burden on subjects and tissue destruction that may influence blood flow itself. On the other hands, noninvasive methodologies such as laser Doppler flowmetry and thermography could primarily measure and evaluate superficial skin blood flow response. In vivo near-infrared spectroscopy (NIRS) is a noninvasive technology for measuring muscle blood volume and oxygenation response with a depth of ~2cm from the skin surface (Hamaoka et al., 2007), which is suitable for assessing the effect of acupuncture on deep tissue blood flow and metabolic response.

First, we documented in the section 2.1 whether AS would provoke vasodilatation in the trapezius muscle and whether the influence of AS would propagate to a region distant from the stimulation point (spatial distribution of the stimulation). Further, the temporal response at the stimulation onset was also examined.

In the section 2.2, we reported the trapezius muscle blood volume and oxygenation in the stimulation region during four different acupuncture techniques, which are popular intervention techniques in Japan.

In the section 2.3, we described the trapezius muscle blood volume and oxygenation in the stimulation region for acupuncture-experienced and non-experienced individuals.

In the section 2.4, we documented the trapezius muscle blood volume and oxygenation in the stimulation region for individuals with and without shoulder stiffness, which originally motivated us to begin a series of experiment.

In the section 2.5, we examined the effects of acupuncture on the autonomic system and the trapezius muscle blood volume and oxygenation.

Finally, we examined in the section 2.6 that moxibustion, a potential analogous stimulus with acupuncture, would influence the trapezius muscle blood volume and oxygenation.

2. The effects of acupuncture and moxibustion

2.1 The effect of acupuncture on temporal and spatial blood volume and oxygenation response in muscle

In this section, we mentioned the trapezius muscle blood volume and oxygenation in the stimulation region and in a distant region in the same muscle during AS based on the reported literature (ohkubo et al. 2009).

There is no evidence whether the influence of AS would propagate to a region distant from the stimulation point across a single muscle. No temporal data either has ever been investigated regarding blood flow response at the onset of AS in humans. Thus, we compare the trapezius muscle blood volume and oxygenation in the stimulation region and in a distant region in the same muscle during AS and to estimate a latency at the onset of AS. We hypothesized that AS provokes a localized increase in muscle blood volume and oxygenation in the stimulation region.

Nine healthy acupuncture-experienced subjects who volunteered from a group of qualified acupuncture therapists were recruited for the experiment. Muscle oxygenation and blood volume were measured by a near-infrared spectrometer (Model HEO-200, OMRON Ltd. Inc., Japan). The equipment has a flexible probe consisting of 2 LEDs that emit light at 760 nm or 840 nm. The light can penetrate soft tissue up to approximately 2.0 cm when the detector is at a distance of 4 cm from the radiation source. Relative changes in oxygenated haemoglobin (oxy-Hb), deoxygenated Hb (deoxy-Hb), and total Hb (t-Hb) were calculated by the equation reported in a previous study (Shiga et al., 1997). However, continuous wave NIRS could not provide absolute values because of unknown physical properties such as the optical path length in tissue (Hamaoka et al., 2007; McCully & Hamaoka, 2000). Usually, arterial occlusion to the limbs makes it possible to produce zero physiological oxygenation and to compare NIRS values among varied individuals and different regions (Hamaoka et al., 1996). However, since the arterial occlusion method could not be applied to the shoulder muscle, oxygenation could not be quantified in the muscle of shoulder stiffness origination. To compare muscle oxygenation in the trapezius, isometric maximum voluntary contraction (MVC) was used in an attempt to induce maximal deoxygenation in the muscle (Matsumoto et al., 2005; Okubo et al., 2000). However, studies on this topic do not entirely address whether the MVC method can create maximal deoxygenation during the contraction and maximal post-contraction hyperemic response consistently in all subjects. Corrected concentrations (mM) considering the subcutaneous adipose tissue thickness (ATT) for oxy-Hb, deoxy-Hb, and t-Hb were obtained by dividing the concentrations with normalized measurement sensitivity S as shown in the literature (Niwayama et al., 2002). Two sets of

NIRS probes, with 40-mm light-source detector spacing, were placed on the right trapezius muscle, with a 50-mm distance between the probes (Fig.1).

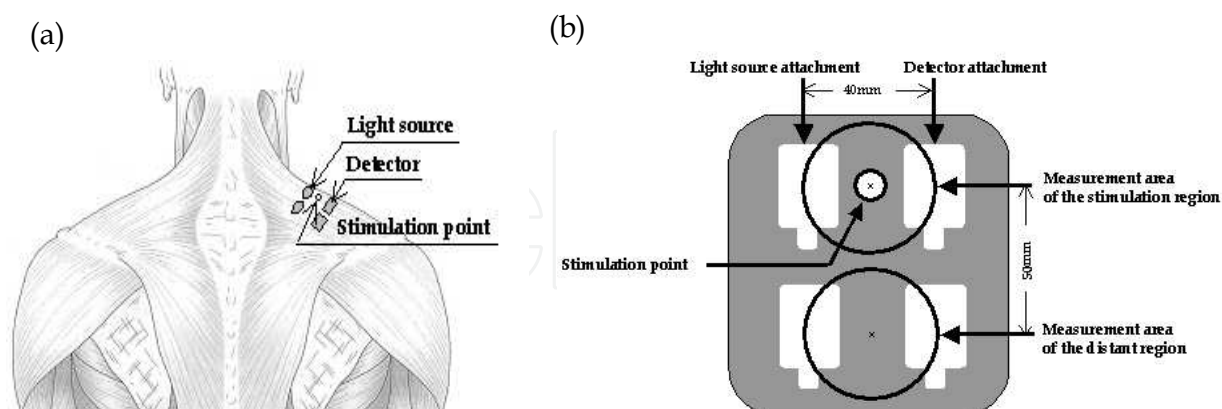


Fig. 1. Measurement site and stimulation point (a) and magnified measurement area and stimulation point (b)

NIRS probes were placed on the belly of the right trapezius muscle of the shoulder, with a 50-mm separation between probes (Fig. 1a & 1b). The measurement range is in the hemisphere of 1/2 of the distance between the light source and detector (20 mm) (Chance et al., 1992). It is necessary to separate the measurement areas by 40 mm or more to prevent the near-infrared rays interfering when two NIRS are measured simultaneously. Therefore, we assumed a distance of 50 mm in consideration of this issue (Fig. 1 b). Changes in muscle oxygenation (oxy-Hb) and blood volume (t-Hb) in stimulation and distant regions (50 mm away from the stimulation point) were measured.

In this experiment, we determined the stimulation point anatomically in the center of the line which tied up the acromion edge to the seventh cervical spine spinous process. This position is the same as GB21 (Jianjing) unified by WHO/WPRO (WPRO, 2008). The other probe located on the same muscle, 50 mm away from the stimulation region, was provided as the reference point (distant region). Measurements began with a 3-min rest period, followed by "Jakutaku" (AS) for 2 min, and recovery after stimulation.

There was no change in any parameters for the control group. There was a significant increase in oxy-Hb and t-Hb in the stimulation region compared to the distant region (Fig.2). Although the distribution of C polymodal nociceptors has been examined in the skin of human limbs but not in the muscle (Ochoa & Torebjork, 1989), the results of this study indicated that the effect of the AS might be, at most, localized ~3 cm away from the AS point or an area ~57 cm³. One might argue that the increases in oxy-Hb and t-Hb found in this study could be due to vasodilatation of the skin. However, since the path of the photons follows the so-called banana-shaped characteristics, the contribution of the skin to the signal should be far less than that of the muscle when an appropriate source-detector spacing of 4 or 5 cm is used (Chance et al., 1992; Ferrari et al., 2004). In the stimulation region, a significant increase in oxy-Hb and t-Hb compared with the pre-stimulation level was first noted at approximately 58 s and 14 s, respectively, after the onset of stimulation. A slower response for oxy-Hb suggests that refilling of oxygenated blood into the small vessels, especially to the capillaries and venules, required a certain length of time after vasodilatation of the arterioles and venules where AS-induced vasodilators might directly

have an influence. The delayed vasodilatation response (14-s latency for the increase in t-Hb after stimulation) might be due to the nature of the response time for nociceptors and C-fibres. It has been reported that vasodilatation induced by the stimulation of peripheral terminals of nociceptors develops with a latency of 15–20 s and outlasts the time of stimulation (Häbler et al., 1997). It has also been suggested that C-fibre activation evokes an ~5-s delay from the onset of AS at a very low (1 Hz) frequency of stimulation (Ochoa & Torebjork, 1989). The long-lasting effects, even after the termination of stimulation where the needle remains stationary, on hyperoxygenation indicate that vasoactive substances such as calcitonin gene-related peptide (CGRP) from the sensory nerve terminals are involved in the mechanisms (Sandberg et al., 2003).

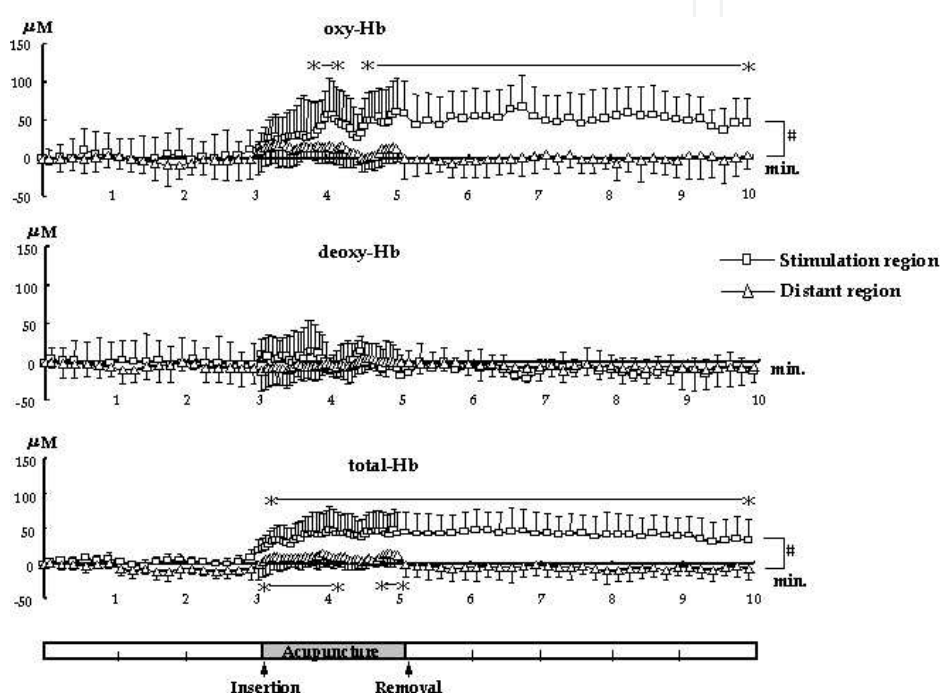


Fig. 2. Changes in oxy-Hb, deoxy-Hb, and t-Hb at pre-stimulation rest and during acupuncture stimulation (AS) and recovery from AS in the stimulation and distant regions in the trapezius muscle

In this study, it is suggested that vasodilative substances induced by AS, mediated by the axon reflex via polymodal receptors in the skeletal muscle and the skin, played a role in the local muscle oxygenation response to the stimulation. The oxygenation and blood volume response was localized to the region where AS was applied.

2.2 The effect of varying acupuncture techniques on muscle blood volume and oxygenation response

In this section, we compared the trapezius muscle blood volume and oxygenation in the stimulation region during four different acupuncture techniques that we have selected as typical interventions in Japan.

Nine healthy acupuncture-experienced subjects who volunteered from a group of qualified acupuncture therapists were recruited for the experiment. Muscle oxygenation and blood volume were measured by a near-infrared spectrometer (Model HEO-200, OMRON Ltd.

Inc., Japan). The equipment has a flexible probe consisting of 2 LEDs that emit light at 760 nm or 840 nm. The light can penetrate soft tissue up to approximately 2.0 cm when the detector is at a distance of 4 cm from the radiation source. Relative changes in oxygenated haemoglobin (oxy-Hb), deoxygenated Hb (deoxy-Hb), and total Hb (t-Hb) were calculated by the equation reported in a previous study (Shiga et al., 1997). Corrected concentrations (mM) considering the subcutaneous adipose tissue thickness (ATT) for oxy-Hb, deoxy-Hb, and t-Hb were obtained by dividing the concentrations with normalized measurement sensitivity *S* as shown in the literature (Niwayama et al., 2002). Two sets of NIRS probes, with 40-mm light-source detector spacing, were placed on the right trapezius muscle, with a 50-mm distance between the probes.

Measurements began with a 3-min rest period, followed by one out of four different acupuncture techniques in random order each for 2 min, and recovery after stimulation. Four different acupuncture techniques are static "Chishin method" (retaining needle) and three dynamic methodes such as "Jakutaku method" (small vertical motion), "Sennen method" (half spin returning) and "Shinsen method" (delicate vibration).

We found the increase in blood volume and oxygenation during acupuncture stimulation for all techniques. The kinetics for static stimulation is illustrated in Fig. 3a. However, techniques for static stimulation produced smaller response than the dynamic ones (Fig. 3b), indicating dynamic stimulation is one of the important factors for creating greater vasodilation response by acupuncture. The increase in oxy-Hb and t-Hb during and after stimulation found in this study indicates enhanced blood flow (oxygen supply) to the small vessels, including arterioles, capillaries, and venules (McCully & Hamaoka, 2000). The increase in blood volume is faster than that of oxygenation, which indicates that arteriolar vasodilatation primarily occurs and then oxygenated blood enters into the capillary networks resulting in the increase in tissue oxygenation.

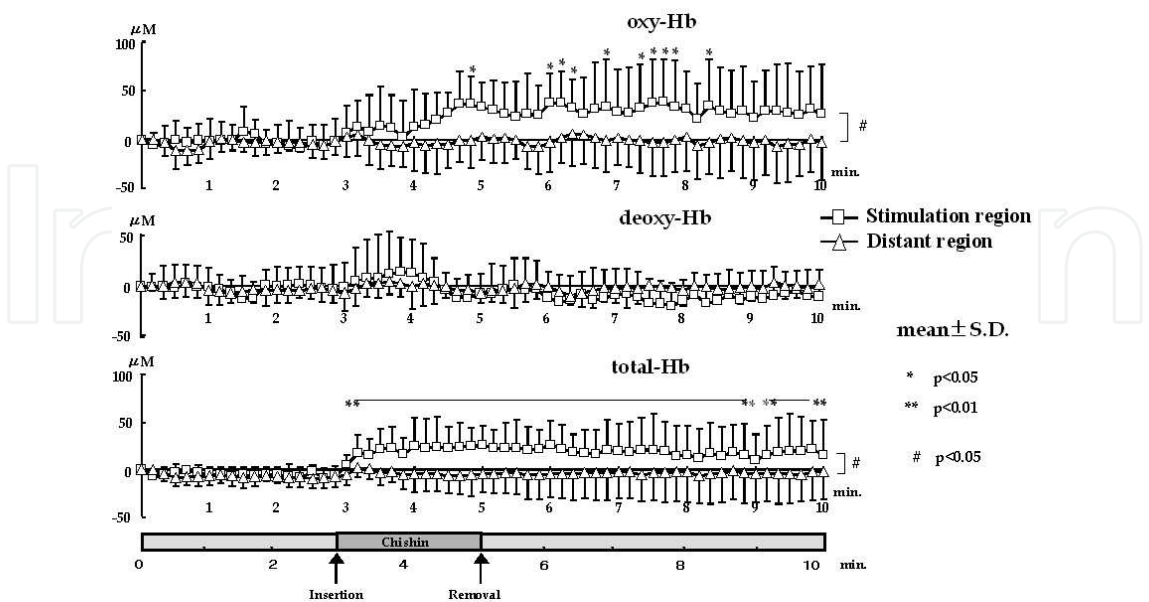


Fig. 3a. Changes in oxy-Hb, deoxy-Hb, and t-Hb at pre-stimulation rest and during static acupuncture stimulation (AS) and recovery from AS in the stimulation and distant regions in the trapezius muscle

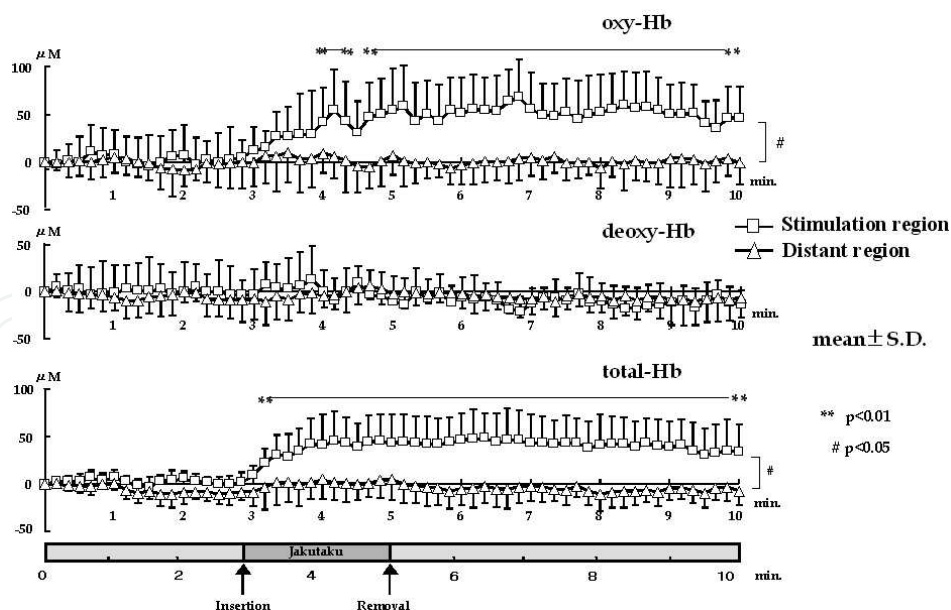


Fig. 3b. Changes in oxy-Hb, deoxy-Hb, and t-Hb at pre-stimulation rest and during dynamic (Jakutaku) acupuncture stimulation (AS) and recovery from AS in the stimulation and distant regions in the trapezius muscle

2.3 The difference in muscle blood volume and oxygenation response between acupuncture-experienced and non-experienced individuals

In this section, we compared the trapezius muscle blood volume and oxygenation in the stimulation region for acupuncture-experienced and non-experienced individuals.

The subjects in the study consisted of 7 healthy acupuncture-experienced adults and 5 healthy non-experienced adults. Muscle oxygenation and blood volume were measured by a near-infrared spectrometer (Model HEO-200, OMRON Ltd. Inc., Japan). The muscle blood volume was measured by placing the light source and the detector 40 mm apart and the middle point between the light source and the detector of the right shoulder was used as the stimulation point. Measurements began with a 3-min rest period, followed by “Jakutaku” acupuncture stimulation without provoking the de-qi sensation for 2 min, and recovery after stimulation. After 15 minutes, isometric contraction of the trapezius was carried out for 20 seconds, and the change was measured during the following 5 minutes.

To compare muscle oxygenation in the trapezius, isometric maximum voluntary contraction (MVC) was used in an attempt to induce maximal deoxygenation in the muscle (Matsumoto et al., 2005; Okubo et al., 2000). The blood volume of the trapezius was calibrated as the ratio of the peak value after isometric contraction of the muscle to the blood volume change during acupuncture stimulation (Fig. 4).

We found the increase in blood volume and oxygenation during acupuncture stimulation for both groups (Fig. 5).

However, the vasodilatation response was greater for acupuncture-experienced individuals, indicating some psychological factors may play a role for blunted response for non-experienced individuals. For examples, the increase in sympathetic activity to the vessels in muscle provoked by anxiety for the intervention may one of the causes for the blunted response. Regarding the effects of blood flow, eliciting the de-qi sensation is superior to merely inserting the needle into the muscle (Sandberg et al., 2003). However, insertion into

the muscle without de-qi sensation resulted in a greater increase in blood flow than that into the skin (Sandberg et al., 2003). Painful sensation is not evoked by microstimulation of C-fibre afferents at frequencies less than 2 Hz and even low-discharge frequency stimuli might induce some physiological effects in subjects without any de-qi sensation (Kawakita et al., 2006). Taken together, the stimulation, regarded as low- to moderate-intensity even without the de-qi sensation used in this study, is effective for creating a vasodilatation response, presumably with the presence of C-fibre stimuli without any de-qi sensation and pain.

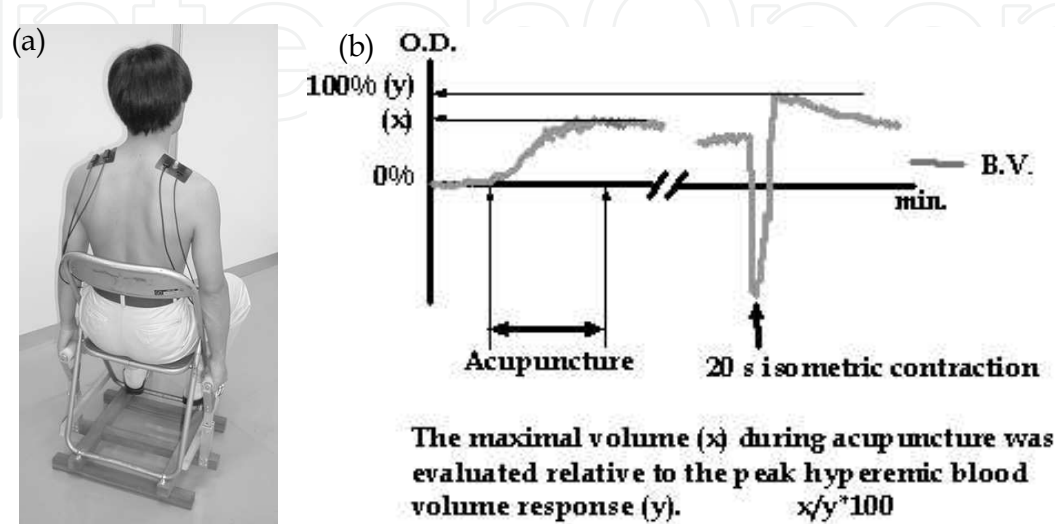


Fig. 4. Experimental setup for NIRS calibration using isometric contraction of the trapezius (a) and representative change in blood volume during acupuncture stimulation, 20 s isometric contraction, and recovery after contraction (b)

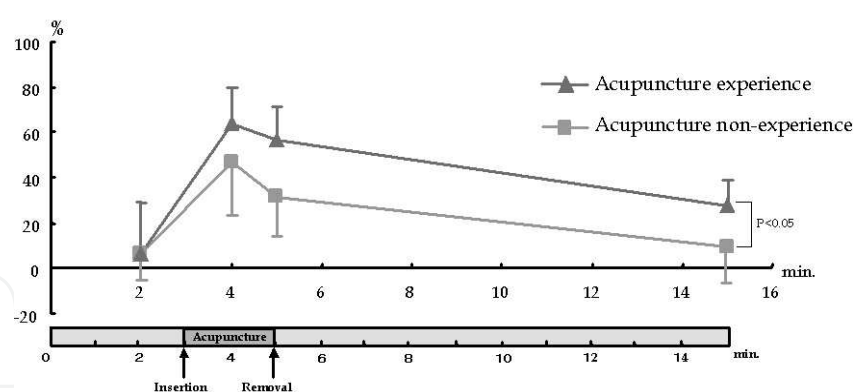


Fig. 5. Changes in blood volume for acupuncture experienced and non-experienced individuals

2.4 The difference in muscle blood volume and oxygenation response between individuals with and without shoulder stiffness

In this section, we attempted to elucidate the difference in vasodilatation response between individuals with and without shoulder stiffness. We compared the trapezius muscle blood volume and oxygenation in the stimulation side where stiffness is prominent for individuals with symptoms and in the non-stimulation contra-lateral shoulder for individuals with and without shoulder stiffness.

The subjects in the study consisted of 6 adults suffering from a shoulder stiffness and 7 healthy adults. Muscle oxygenation and blood volume were measured by a near-infrared spectrometer (Model HEO-200, OMRON Ltd. Inc., Japan). The muscle blood volume was measured by placing the light source and the detector 40 mm apart and the middle point between the light source and the detector of the right shoulder was used as the stimulation point. Measurements began with a 3-min rest period, followed by “Jakutaku” acupuncture stimulation without provoking the de-qi sensation for 2 min, and recovery after stimulation. After 15 minutes, isometric contraction of the trapezius was carried out for 20 seconds, and the change was measured during the following 5 minutes. To compare muscle oxygenation in the trapezius, isometric maximum voluntary contraction (MVC) was used in an attempt to induce maximal deoxygenation in the muscle (Matsumoto et al., 2005; Okubo et al., 2000). The blood volume of the trapezius was calibrated as the ratio of the peak value after isometric contraction of the muscle to the blood volume change during acupuncture stimulation.

Measurements began with a 3-min rest period, followed by the acupuncture into the trapezius muscle for 2 min, and recovery after stimulation. After 15 minutes, isometric contraction of the trapezius was carried out for 20 seconds, and the change was measured during the following 5 minutes. Muscle oxygenation and blood volume were measured using near-infrared spectrometer (Model HEO-200, OMRON Ltd. Inc., Japan).

We found the increase in blood volume and oxygenation during acupuncture stimulation for both groups in the stimulation shoulder with the response being smaller in the symptom (+) group (Fig. 6).

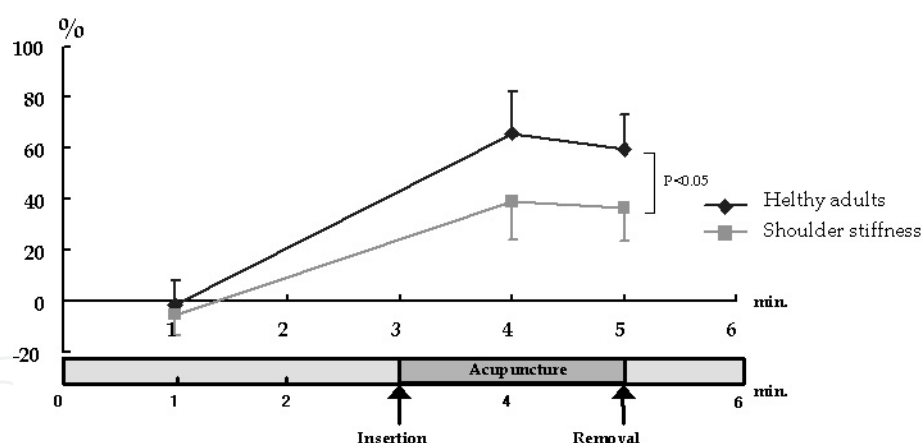


Fig. 6. Changes in blood volume for individuals with and without shoulder stiffness

The response was similar for the two groups in the non-stimulation shoulder, but subjective pain relief was only found in stimulation region for shoulder stiffness individuals. The result of this study indicates that the pain relief response by acupuncture could be brought about only in the stimulation side, presumably due to some local responses such as C-fibre mediated axon reflex.

It is believed that shoulder discomfort occurs due to blood flow restriction resulted from the increase in muscle stiffness and vasoconstriction. The results of this study may be explained by the greater sympathetic nerve activity (SNA) against local metabolic vasodilatation activity for individuals with shoulder stiffness.

2.5 The difference of acupuncture on autonomic system and localized trapezius blood volume and oxygenation responses

In this section, we examined the effects of acupuncture on the autonomic system and the trapezius muscle blood volume and oxygenation.

The subjects in the study consisted of 9 healthy adults. Muscle oxygenation and blood volume were measured by a near-infrared spectrometer (Model HEO-200, OMRON Ltd. Inc., Japan). The equipment has a flexible probe consisting of 2 LEDs that emit light at 760 nm or 840 nm. The light can penetrate soft tissue up to approximately 2.0 cm when the detector is at a distance of 4 cm from the radiation source. Relative changes in oxygenated haemoglobin (oxy-Hb), deoxygenated Hb (deoxy-Hb), and total Hb (t-Hb) were calculated by the equation reported in a previous study (Shiga et al., 1997). However, continuous wave NIRS could not provide absolute values because of unknown physical properties such as the optical path length in tissue (Hamaoka et al., 2007; McCully & Hamaoka, 2000). Usually, arterial occlusion to the limbs makes it possible to produce zero physiological oxygenation and to compare NIRS values among varied individuals and different regions (Hamaoka et al., 1996). However, since the arterial occlusion method could not be applied to the shoulder muscle, oxygenation could not be quantified in the muscle of shoulder stiffness origination. To compare muscle oxygenation in the trapezius, isometric maximum voluntary contraction (MVC) was used in an attempt to induce maximal deoxygenation in the muscle (Matsumoto et al., 2005; Okubo et al., 2000). However, studies on this topic do not entirely address whether the MVC method can create maximal deoxygenation during the contraction and maximal post-contraction hyperemic response consistently in all subjects. Corrected concentrations (mM) considering the subcutaneous adipose tissue thickness (ATT) for oxy-Hb, deoxy-Hb, and t-Hb were obtained by dividing the concentrations with normalized measurement sensitivity S as shown in the literature (Niwayama et al., 2002). Two sets of NIRS probes, with 40-mm light-source detector spacing, were placed on the right trapezius muscle, with a 50-mm distance between the probes.

The sensor of the tonometry device was placed over the left radial artery and the manchette on the left upper arm to monitor the peripheral volumetric pulse waveform and blood pressure (BP). Electrocardiogram (ECG) electrodes were placed on the chest to monitor the heart rate (HR) during the experiment. The subjects were instructed to report the perceived sensation at the end of AS to evaluate a subjective perception of the stimulation. The BP and R-R interval were continuously measured using applanation tonometry and HR monitors, respectively (BP-508, Colin Medical Instruments). The HR and BP recordings were sampled at 2 Hz each during 128-s intervals. All data were acquired via ANS-508 (Colin Medical) and digitized for beat-to-beat R-R interval variability analysis. The frequency domain variables high- (HF, 0.15–0.40 Hz) and low-frequency power (LF, 0.04–0.15 Hz) and the LF/HF-ratio (LF/HF) were analyzed using fast Fourier transform (FFT).

There was a significant increase in oxy-Hb and t-Hb in the stimulation region as shown in Fig. 2. The data for HR, BP, LF, and LF/HF were averaged from 1 to 3 min at rest, from 3 to 5 min during stimulation, and from 8 to 10 min after stimulation; they were denoted as PRE, STM, and PST, respectively. The HR during STM (69.1 ± 7.7 bpm) was significantly lower than that at PRE (74.2 ± 7.8 bpm) and PST (73.3 ± 8.2 bpm) (Fig. 7). There were no significant changes in systolic BP (SBP), diastolic BP, or mean BP. The HF and LF/HF values obtained from HR variability did not show any significant changes throughout the AS experiment. The LF values obtained from SBP variability did not show any significant changes throughout the AS experiment. We found a decreased HR without any modification of sympathetic and parasympathetic activities and the increase in blood volume and

oxygenation during acupuncture stimulation. The peripheral blood pressure and sympathetic responses did not change by acupuncture.

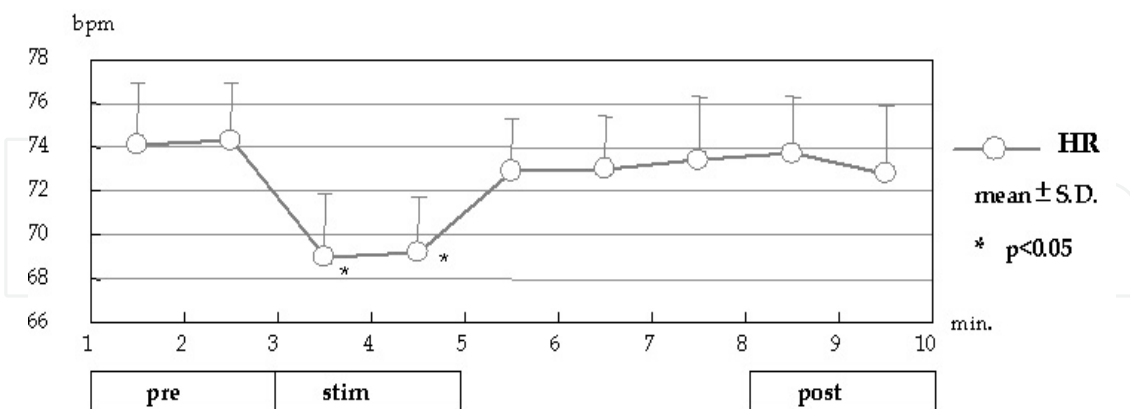


Fig. 7. Change in heart rate (HR) by acupuncture stimulation

We found no changes in LF power for BP variability, an indicator for peripheral SNA, evaluated by the tonometry of the radial artery both during and after AS and MS. There are several reports regarding the influence of AS on SNA in animals and humans. In the line of the results obtained from hypertensive animal experiments (Yao et al., 1982), Knardahl et al. (1998) hypothesized that SNA would decrease during AS by reducing stress. However, they found an increase in SNA during AS in humans. They speculated that the discrepancy between the finding in hypertensive animals (Yao et al., 1982) and the lack of acupuncture-induced sympathoinhibition (Knardahl et al., 1998) could be attributable to a difference in responsiveness related to normo- versus hypertension. However, there is also some evidence for decreasing blood pressure via acupuncture-induced suppressed response of SNA even in normotensive animal experiments (Ohsawa et al., 1995). The discrepancy in SNA response reported in the study of Knardahl et al. (1998) and ours might be due to the degree of central command or mental stress from the AS that is known to bring about an increase in SNA (Anderson et al., 1987).

Central circulation is one of the determinant factors for peripheral circulation. In this study, we did not find any changes in the parameters related to cardiac output (CO) except for HR (an average decrease of 5 rpm during AS, but a return to the baseline levels after AS). Since BP and SNA, indicators of peripheral resistance, and the cardiac sympathetic/parasympathetic activity did not change during AS, it is speculated that the CO remained relatively constant during and after AS. Further, muscle oxygenation levels remained elevated after AS, whereas the HR returned to the pre-AS resting levels following the decrease during AS. Therefore, there is no influence of the central circulation on the response of local muscle oxygenation changes during and after AS. Usually, a parallel decrease in HR is observed with acupuncture-induced BP increase as a result of a baroreflex response (Nishijo et al., 1997; Lin et al., 2000). After the end of the stimulation, a parasympathetic tone or a decreased sympathetic tone appears dominant (Jänig, 1995).

In contrast, weaker stimuli may induce a decrease in both BP and HR (Damen and Brunia, 1987). However, we found only a decrease in HR without any changes in BP or sympathetic activity during and after AS. The study (Nishijo et al., 1997) examined HR response following AS with the administration of atropine and propranolol in conscious humans. Vagal nerves as well as sympathetic nerves can respond well to AS, being moved up and down about 5 mm at a frequency of 1 Hz with a 20 mm insertion depth. The mechanism

attributable to reducing the HR in this study might be the dominant activation of the parasympathetic cholinergic system or cardiac vagal activation.

2.6 The effect of moxibustion on localized trapezius blood volume and oxygenation response

We examined the effects of moxibustion, a potential analogous stimulus with acupuncture, on the trapezius muscle blood volume and oxygenation. The subjects in the study consisted of 9 healthy adults. Muscle oxygenation and blood volume were measured by a near-infrared spectrometer (Model HEO-200, OMRON Ltd. Inc., Japan). The equipment has a flexible probe consisting of 2 LEDs that emit light at 760 nm or 840 nm. The light can penetrate soft tissue up to approximately 2.0 cm when the detector is at a distance of 4 cm from the radiation source. Relative changes in oxygenated haemoglobin (oxy-Hb), deoxygenated Hb (deoxy-Hb), and total Hb (t-Hb) were calculated by the equation reported in a previous study (Shiga et al., 1997). Corrected concentrations (mM) considering the subcutaneous adipose tissue thickness (ATT) for oxy-Hb, deoxy-Hb, and t-Hb were obtained by dividing the concentrations with normalized measurement sensitivity *S* as shown in the literature (Niwayama et al., 2002). Two sets of NIRS probes, with 40-mm light-source detector spacing, were placed on the right trapezius muscle, with a 50-mm distance between the probes.

The warming moxa (Kamaya moxa Co. Ltd.) was placed on the stimulation point, and the timing for the ignition was adjusted such that the subjects experienced a thermal perception 3 min after the start of the measurement. The measurement was continued for 7 min thereafter (total: 10 min).

We found a robust increase in localized blood volume and oxygenation during and after moxibustion stimulation periods and the increase was larger than that of acupuncture. The magnitude of stimulation could be greater in moxibustion than that of acupuncture, but the response is still localized and is not propagated to the contralateral trapezius (Fig. 8).

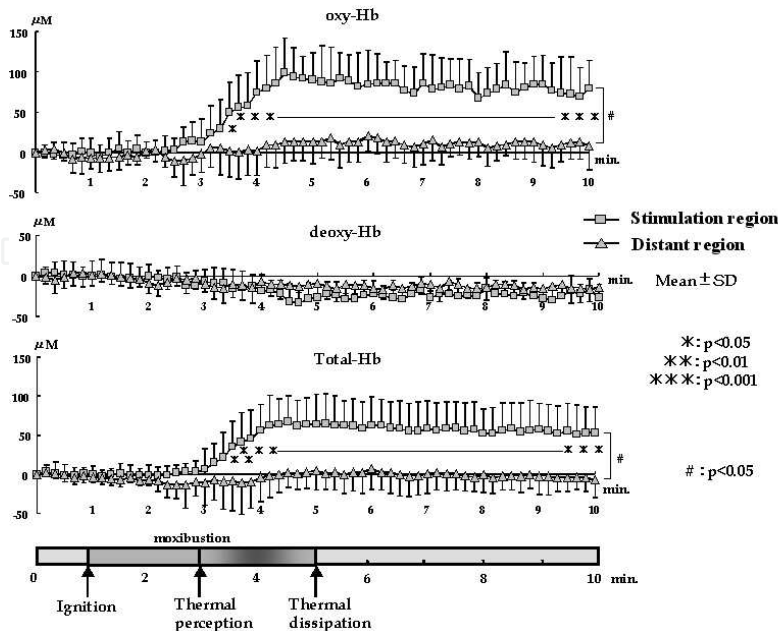


Fig. 8. Changes in oxy-Hb, deoxy-Hb, and t-Hb at pre-stimulation rest and during moxibustion stimulation (MS) and recovery from MS in the stimulation and distant regions in the trapezius muscle

It is suggested that vasodilative metabolites induced by MS, presumably mediated by the axon reflex via polymodal receptors in the skeletal muscle and the skin, attributed to the local muscle oxygenation response to the stimulation. The oxygenation and blood volume response was localized to the region where MS was applied similar to the AS.

3. Summary

In this study, vasodilative substances induced by AS and MS, mediated by the axon reflex via polymodal receptors in the skeletal muscle and the skin, played a role in the local muscle oxygenation response to the stimulation. The oxygenation and blood volume response was localized to the region where AS and MS were applied. However, techniques for static AS produced smaller response than the dynamic ones, indicating dynamic stimulation is one of the important factors for creating greater vasodilation response by acupuncture.

The vasodilatation response was greater for acupuncture-experienced individuals, indicating some psychological factors may play a role for blunted response for non-experienced individuals. We found the increase in blood volume and oxygenation during acupuncture stimulation for both groups in the stimulation shoulder with the response being smaller in the symptom (+) group. The HR during AS was lowered, but BP and cardiac and peripheral SNA did not change. We found a robust increase in localized blood volume and oxygenation during and after moxibustion stimulation periods and the increase was larger than that of acupuncture.

NIRS is able to provide an objective indication for examining the degree of vasodilatation (hyperoxygenation) response. Monitoring NIRS indications would be useful, in particular, for treating patients with shoulder stiffness or muscle spasms to determine the optimal intensity and frequency of AS and MS.

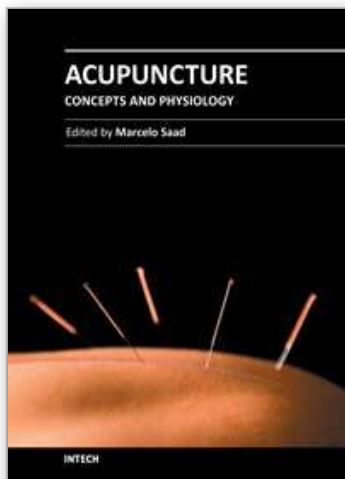
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Acupuncture and related techniques are useful tools for treating a spectrum of diseases. However, there are still many areas of controversy surrounding it. We hope this book can contribute to guide the advance of this ancient medical art. In the present work, the reader will find texts written by authors from different parts of the world. The chapters cover strategic areas to collaborate with the consolidation of the knowledge in acupuncture. The book doesn't intend to solve all the questions regarding this issue but the main objective is to share elements to make acupuncture more and better understood at health systems worldwide.

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