Changes in Blood Circulation of the Contralateral Achilles Tendon During and After Acupuncture and Heating

Authors K. Kubo[1], H. Yajima[2], M. Takayama[2], T. Ikebukuro[3], H. Mizoguchi[4], N. Takakura[2]

Affiliations
[1] Life Science (Sports Sciences), University of Tokyo, Japan
[2] Tokyo Ariake University of Medical and Health Sciences, Department of Acupuncture and Moxibustion, Tokyo, Japan
[3] Kokushikan University, Physical Education, Tokyo, Japan
[4] Hanada College, Moxibustion and Physiotherapy, Tokyo, Japan

Key words
- needle
- hot pack
- recovery
- plantar flexors

Abstract

The purpose of this study was to investigate the effects of acupuncture and heating (application of hot pack) treatments on blood circulation in the contralateral Achilles tendon. During the treatments (10 min for acupuncture, 20 min for heating) and recovery period (40 min), the blood volume (THb) and oxygen saturation (StO_2) of the treated and the non-treated tendons were measured using red laser lights. During both treatments, THb and StO_2 of the treated tendon increased significantly from the resting level. The increased THb and StO_2 of the treated tendon were maintained until the end of the recovery period after removal of the acupuncture needle, although these values decreased after removal of the hot pack. Although THb of the non-treated sides did not change during both acupuncture and heating treatments, it increased gradually after removal of the acupuncture needle or the hot pack. For both treatments, the amount of increase in THb of the non-treated tendon was significantly correlated to that of the treated tendon during the last phase of recovery period. These results obtained from the healthy subjects imply that blood circulation in the injured tendon in a plaster cast may be improved by applying acupuncture or heating treatments to the contralateral healthy limb.

Introduction

Some previous studies demonstrated that acupuncture and heating treatments were useful to cure the injured tissues (muscle, tendon, ligament, etc) in the athletic and the medial field e.g., [10,15]. These treatments are expected to improve blood flow to the injured tissues. The previous studies using animals and humans showed that the blood flow to the skin and the muscle increased considerably during acupuncture and heating e.g., [1,28]. More recently, we reported that the blood volume and oxygen saturation of the human Achilles tendon increased during both acupuncture and heating [18]. In addition, we demonstrated that the blood volume of the tendon remained high throughout the recovery period (30 min) after acupuncture, although this value was not maintained after heating. However, the mechanisms of these phenomena are unknown.

According to the previous reports, the blood flow of the skin and the muscle of the non-treated site and/or contralateral limb increased when acupuncture and heating treatments were applied [2,3,7,19,20]. For example, Marshall et al. [20] reported that the blood flow of the skin increased in the hand when heat was applied to the contralateral hand. Furthermore, Ernst and Lee [7] also showed that when the acupuncture was applied to the hand, the superficial temperature of the non-treated sites (face and foot) as well as the treated site (hand) increased during and after acupuncture. They suggested that these interesting phenomena were brought about by a central effect, i.e., the spinal or the supra-spinal sympathetic reflex, rather than a peripheral effect. Considering these previous findings, it seems likely that the blood circulation of the non-treated (contralateral) tendon as well as the treated one changes during and after acupuncture and heating treatments.

In this study, we investigated the changes in the blood volume and oxygen saturation of the human Achilles tendon for both treated and non-treated sides during and after acupuncture or heating treatments. We hypothesized that the blood circulation of the non-treated tendon can be changed as well as the treated one by acupuncture or heating treatments.

accepted after revision
April 19, 2011

Bibliography
DOI http://dx.doi.org/10.1055/s-0031-1277213
Published online: May 26, 2011
Int J Sports Med 2011; 32: 807–813 © Georg Thieme Verlag KG Stuttgart · New York
ISSN 0172-4622

Correspondence
Dr. Keitaro Kubo
Life Science (Sports Sciences)
University of Tokyo
Komaba 3-8-1
Meguro
Tokyo
153-8902 Tokyo
Japan
Tel.: +81/3/5454 68 64
Fax: +81/3/5454 43 17
kubo@idaten.c.u-tokyo.ac.jp

Methods

Subjects

17 healthy male volunteers (mean ± SD age: 28.4 ± 7.4 years, height: 173.5 ± 5.6 cm, body mass: 72.2 ± 9.9 kg) participated in this study. The subjects were either sedentary, or mildly to moderately active men, but none were involved in any type of resistance exercise program at the time of the study. The subjects were fully informed of the procedures to be utilized as well as the purpose of this study. Written informed consent was obtained from all subjects. We conducted our research ethically according to international standards and as required by the journal as described in Harriss and Atkinson [11]. This study was approved by the office of the Department of Sports Sciences, University of Tokyo, and complied with their requirements for human experimentation.

Acupuncture and heating treatments

The subjects lay prone on a test bench to acclimate to the laboratory conditions for 20 min prior to the experiment. Initially, the subject lay in a comfortable prone position for a 15 min rest period. After that, a needle was inserted (acupuncture) or a hot pack was applied (heating) to the right Achilles tendon. After the needle or the hot pack was removed, the subject remained relaxed in the same position for 40 min. Furthermore, in the control session, the subjects lay in the comfortable prone position for 60 min after a 15 min rest period. Treatments and control sessions were performed for each subject on 3 separate days, with at least 2 weeks between sessions, but no longer than 3 weeks were allowed between the 3 sessions. The order of the execution of the 3 experimental conditions was randomized for each subject.

Acupuncture

An acupuncture treatment was given by one of the authors (H.Y.), who is an experienced licensed acupuncturist. A stainless steel needle of 0.16 mm in diameter and 40 mm in length was inserted vertically into the skin at 40 mm proximal from the calcaneus in the right foot. After the needle insertion to a targeted depth (3 mm) to reach the Achilles tendon, the needle was left in place for 5 min without any manipulations (Acu-1). Then, the needle tip was moved up and down from the targeted depth (up-and-down manipulation) at approximately 1 mm amplitude and 2 Hz for 3 min (Acu-2). After this technique, the needle was left in place for 2 min without manipulations (Acu-3). To verify the precision of this procedure (the needle reached the Achilles tendon), we observed using ultrasonography that the distance from the skin to the superficial surface of the Achilles tendon at 40 mm proximal from the calcaneus was 2.1 ± 0.4 mm. Furthermore, the acupuncturist (H.Y.) confirmed visually and by sense of touch through the needle that the needle had reached the Achilles tendon.

Heating

A hot pack (Kanahot, Tsuten) provided specific localized temperature control. The dimensions of the hot pack were 46 cm by 30 cm, and it was placed so as to cover the posterior surface of the lower leg with the long side placed along the length of the right lower leg. Thus, the hot pack covered the Achilles tendon. The surface temperature of this hot pack was about 55 °C. The hot pack was placed on the Achilles tendon for 20 min. We found that the significant but small amount of changes in THb and StO_2 during 10 min heating returned to the resting level immediately after removal of the hot pack in the treated Achilles tendon [18]. Because of this, obvious change in the contralateral Achilles tendon by 10 min heating could be hardly expected. Further, 15–30 min heating is usually used for the treatment of injuries in the athletic and the medical fields [6, 8, 9]. Thus in this study we decided to use a 20 min heating stimulation. At the end of heating, the temperatures measured by a deep body thermometer (Coretemp CM-210, Terumo Medical Corp.) increased by 5.3 ± 0.8 °C for the tendon and 11.5 ± 1.3 °C for the skin, respectively.

Blood circulation of Achilles tendon

Throughout the experiment, we measured the blood circulation (oxyhemoglobin; Oxy, deoxyhemoglobin; Deoxy, total hemoglobin; THb, oxygen saturation; StO_2) of the Achilles tendon for both the treated and non-treated sides. To measure the blood circulation of the tendon using red laser lights (BOM-L1TRSF, Omega Wave), a probe was positioned at 30 mm proximal from the calcaneus. This instrument uses 3 red laser lights (635, 650, and 690 nm), and calculates the relative tissue levels of Oxy, Deoxy, and THb (corresponding to the blood volume) according to the Beer-Lambert law [4]. The distance between the light source and photodetector was 5 mm. The THb and StO_2 at a specific depth (measurement depth of 3–5 mm) of the tissue could be measured by changing the location of the 2 detectors [14]. The details of this technique and principle of this instrument (red laser lights) have been described in our previous studies [16, 17]. Briefly, two-point detection and the differential calculation method were used to measure the blood circulation only in the deep region of the tissue (see ▶ **Fig. 2** of Ref 16). Oxy, Deoxy, and THb at specific tissue depths could be measured by changing the location of the 2 detectors. The offset values of Oxy, Deoxy, and THb were reduced, and a highly sensitive measurement was achieved using the two-point detection method. The precision and validity of this procedure were presented and discussed in our previous studies [16, 17].

In the present study, the units of Oxy, Deoxy, and THb are expressed as μmol/l, although this does not represent the actual physical volume. StO_2 was calculated from Oxy and THb values using the following formula [16, 17]: StO_2 (%) = 100*Oxy/THb. Our data were entered into a personal computer (Powerbook G4, Apple, Tokyo, Japan) at a sampling frequency of 10 Hz via an A/D transducer (Power Lab, AD Instruments, Australia). The mean values over a given duration {every 1 min during the acupuncture treatment, every 2 min during heating, every 5 min during the recovery period} were calculated using analytical software (Chart ver. 5.4.2, AD Instruments, Australia). Oxy, Deoxy, THb, StO_2 data are presented as the amount of increase from the resting level. The repeatability of the blood circulation (Oxy, Deoxy, THb, and StO_2) measurements for the tendon during resting was investigated in our previous studies [17, 18].

Statistics

Values are reported as means ± standard error of the mean (S.E.M.). Two-way (side x time) ANOVA with repeated measures was used to detect significant differences in the measured variables from the resting level. The F ratios for main effects and interactions were considered significant at $p < 0.05$. When the ANOVA revealed significant main effects for side and time, whether or not there was a significant interaction between them, we returned to one-way ANOVA with repeated measures to detect any significant changes from the resting level. Significant differences among means at $p < 0.05$ were detected using a Tukey post-hoc test. A linear regression analysis was performed on the relationship between the amount of increase in THb of

the treated tendon and the non-treated tendon during the recovery period.

Results

The time course changes in Oxy, Deoxy, THb, and StO_2 of the treated and the non-treated tendons during acupuncture treatment and recovery period are shown in **Fig. 1**. For all the variables, the effects of both side and time were significant, although the interaction between side and time was not significant. All the measured variables did not change during acupuncture without manipulation (Acu-1). During up-and-down manipulation (Acu-2), all the measured variables of the tendon for the treated side increased significantly, although those for the non-treated side did not. During the recovery period, Oxy, THb and StO_2 values of the tendon remained high for the treated side. For the non-treated side, Oxy and THb of the tendon increased gradually. During the latter half of recovery period (21–30 min and 31–40 min), the amount of increase in THb of the non-treated tendon was significantly correlated to that of the treated tendon (**Fig. 2**).

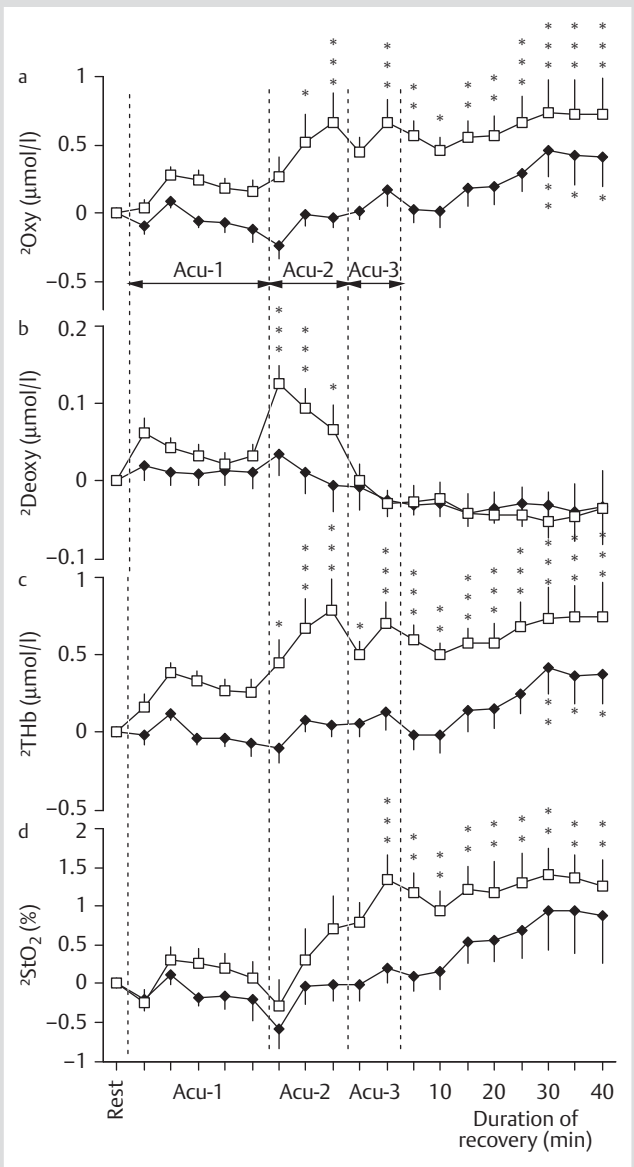

Fig. 1 The time course changes in oxyhemoglobin (Oxy; **a**), deoxyhemoglobin (Deoxy; **b**), total hemoglobin (THb; **c**), and oxygen saturation (StO_2; **d**) of treated tendon (open) and non-treated tendon (closed) during acupuncture treatment and recovery periods.
* significantly different from the resting level (* $p<0.05$, ** $p<0.01$, *** $p<0.001$)

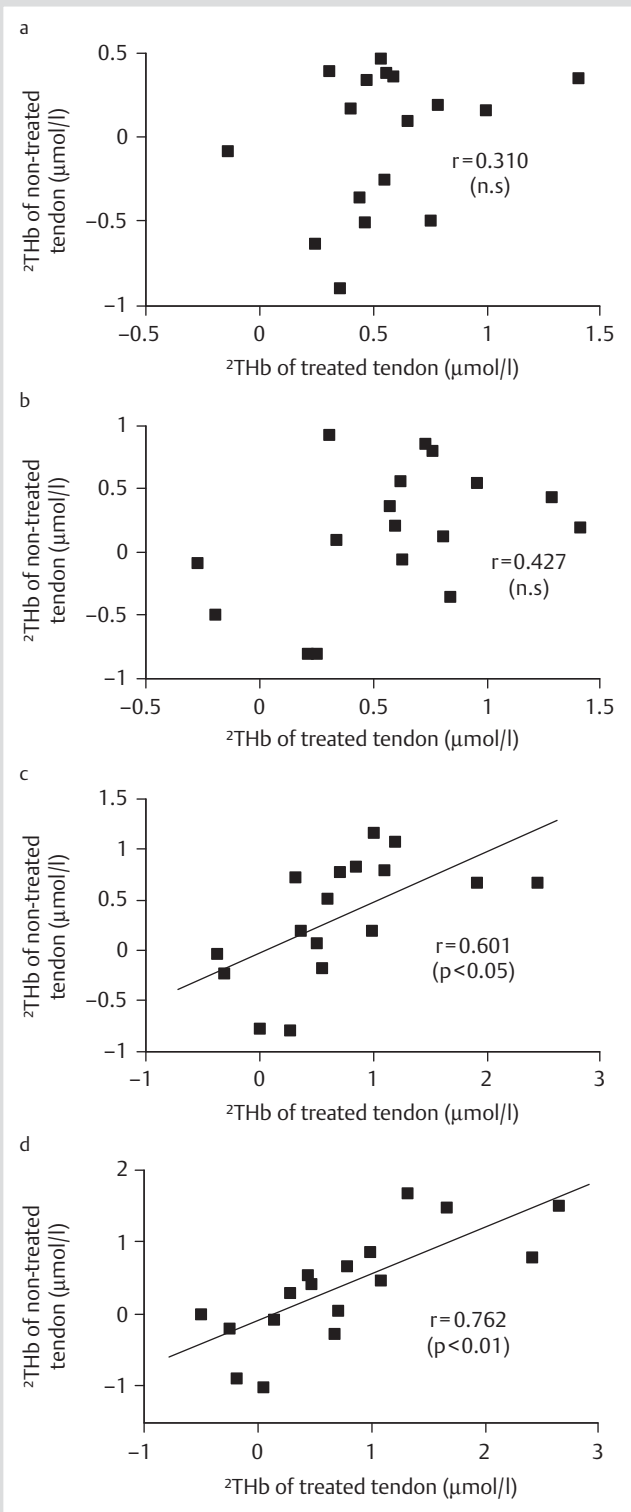

Fig. 2 Relationship between mean increase in total hemoglobin (THb) of treated tendon and non-treated tendon during 0–10 min (**a**), 11–20 min (**b**), 21–30 min (**c**), and 31–40 min (**d**) of the recovery period (after acupuncture treatment).

The time course changes in Oxy, Deoxy, THb, and StO_2 of the treated and the non-treated tendons during heating treatment and recovery period are shown in ▶ **Fig. 3**. For all the variables, the effects of side and time, as well as the interaction between side and time, were significant. During heating treatment, Oxy, THb and StO_2 of the tendon for the treated side increased, but Deoxy decreased, significantly. On the other hand, all the measured variables of the tendon for the non-treated side did not change during heating. During the recovery period, all the measured variables of the tendon for the treated side tended to return to the resting level, however for the non-treated side Oxy, THb and StO_2 of the tendon increased gradually. During the last phase of recovery period (30–40 min), the amount of increase in THb of the non-treated tendon was significantly correlated to that of the treated tendon (▶ **Fig. 4**).

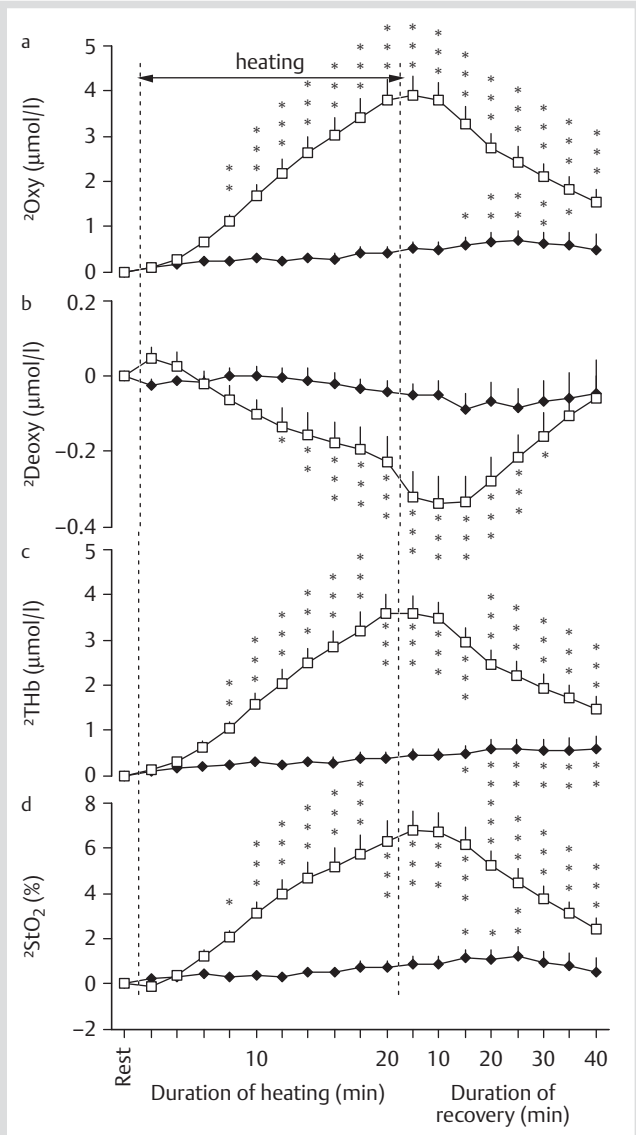

Fig. 3 The time course changes in oxyhemoglobin (Oxy; **a**), deoxyhemoglobin (Deoxy; **b**), total hemoglobin (THb; **c**), and oxygen saturation (StO_2; **d**) of treated tendon (open) and non-treated tendon (closed) during heating treatment and recovery periods.
* significantly different from the resting level (* $p<0.05$, ** $p<0.01$, *** $p<0.001$)

In the control condition (no treatment), all the measured variables of the tendon did not change during the experimental period (▶ **Fig. 5**).

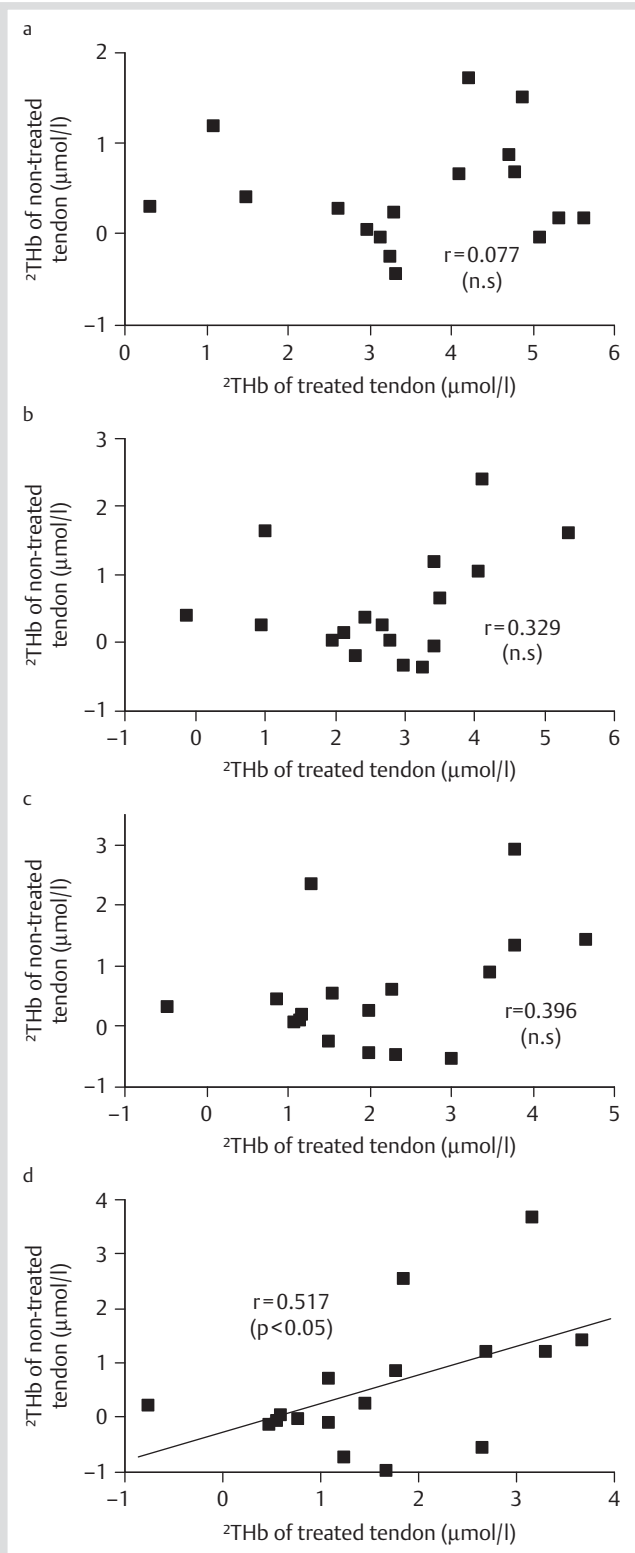

Fig. 4 Relationship between mean increase in total hemoglobin (THb) of treated tendon and non-treated tendon during 0–10 min (**a**), 11–20 min (**b**), 21–30 min (**c**), and 31–40 min (**d**) of the recovery period (after heating treatment).

Discussion

The major findings of this study were that 1) the blood volume of the non-treated tendon increased gradually after removal of the needle and the hot pack, although it did not change during both treatments, 2) the blood volume and oxygen saturation of the treated tendon increased significantly during the acupuncture with up-and-down manipulation and heating treatments, 3) these increased values were maintained after removal of the needle, but decreased after removal of the hot pack in the treated tendon.

During acupuncture with up-and-down manipulation (Acu-2), the blood circulation of the tendon changed dramatically, although it did not change during acupuncture without manipulation (Acu-1), which agreed with our previous finding [18]. In addition, increases in both Oxy and Deoxy would imply that the inflow of blood to the tendon and the metabolism of the tendon increased during Acu-2. Therefore, we may say that the up-and-down manipulation is necessary when we apply acupuncture treatment to the injured tendon. According to some previous studies [22, 24], the manual acupuncture (like Acu-2) in humans caused decrease of heart rate and decrease of muscle sympathetic activity. In addition, Ohsawa et al. [25] reported that twisting a needle at 1 Hz in the skin and underlying muscles induced decrease in renal sympathetic nerve activities in anesthetized rats. At the beginning of the study, therefore, we expected that THb and StO_2 of the non-treated tendon increased during acupuncture, since the changes in blood circulation would be caused by central effects [22, 24, 25]. However, the expected increases in THb and StO_2 were not observed in this study. Sato et al. [29] demonstrated that vasodilation by antidromic calcitonin gene-related peptide via the axon reflex induced by acupuncture increases the blood flow in the muscle in animals. Kashiba and Ueda [13] also stated that the axon reflex would be one of the mechanisms underlying the increases in the blood flow in the skin and the muscle responded to acupuncture stimulation. Taken together, it is likely that the change in blood circulation of the tendon during acupuncture with up-and-down manipulation (Acu-2) is caused by axon reflex rather than somato-viceral reflex.

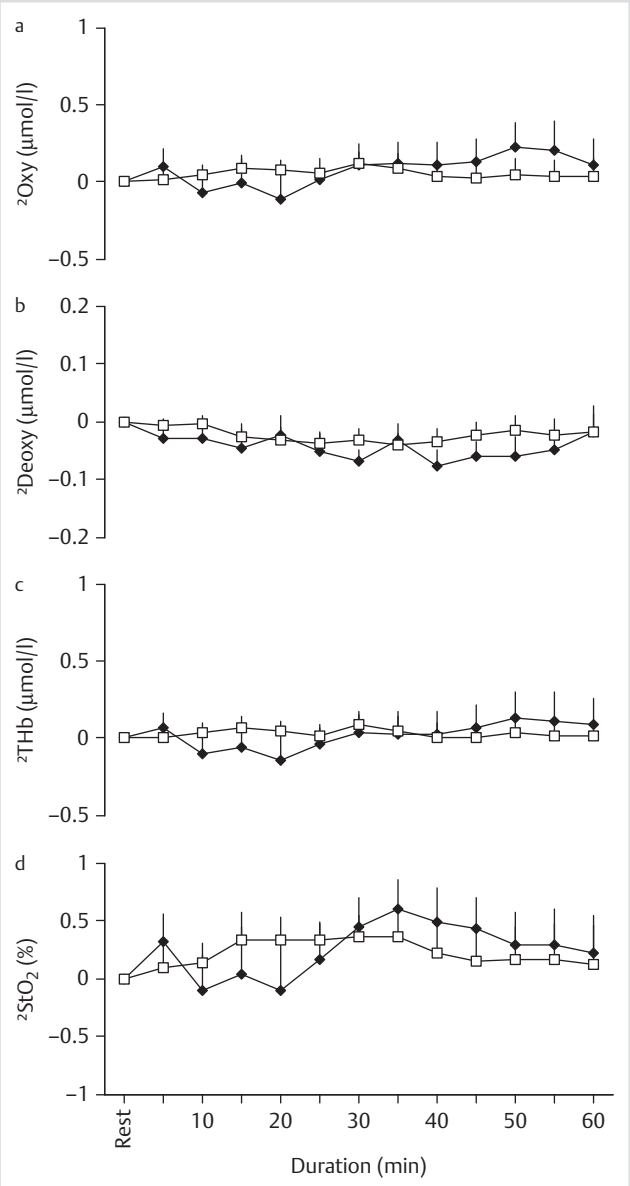

Fig. 5 The time course changes in oxyhemoglobin (Oxy; **a**), deoxyhemoglobin (Deoxy; **b**), total hemoglobin (THb; **c**), and oxygen saturation (StO_2; **d**) of right tendon (open) and left tendon (closed) during no treatment and recovery periods.

After removal of the needle, THb and StO_2 of the tendon increased gradually in the non-treated side, and for the treated side these values remained high (**Fig. 1c, d**). Interestingly, the amount of increase in THb of the non-treated tendon was significantly correlated to that of the treated tendon during the latter half of recovery period (**Fig. 2c, d**). This interesting increase in blood circulation in the untreated tissue after removal of the acupuncture needle has already been reported [7, 19]. Ernst and Lee [7] showed that the skin temperature corresponding to the blood flow in the non-treated face and foot as well as the treated hand increased for a long time after the needle removal. This increased blood circulation of the untreated tissues suggests that the increase in blood flow in the tendons after the needle removal might be caused through the central nervous system (this point was discussed in the fifth paragraph of Discussion section).

During heating treatment, Oxy, THb and StO_2 increased in the treated tendon, but Deoxy decreased (**Fig. 3**). These results implied that during heating the increase in blood inflow to the tendon was considerably higher than an acceleration of the metabolic rate of the tendon. Contrary to the heated tendon, the blood circulation of the non-heated tendon did not change during heating treatment. Previous studies have demonstrated that the blood flow of the skin and the muscle in the hand increased when heat was applied to the contralateral hand [2, 3, 20]. Contrary to this other previous researchers showed no significant change in the blood flow to the skin after contralateral heating [5, 12, 23]. Our result agreed with the latter finding suggesting that the increases in the blood circulation of the tendon occurred peripherally during heating.

Another interesting finding of this study was that THb of the non-heated tendon increased gradually during the recovery period in the same way as acupuncture (**Fig. 3c**). Furthermore, the amount of increase in THb of the non-heated tendon was significantly correlated to that of the treated tendon during the last phase of recovery period (**Fig. 4d**). As far as we know, no studies have shown similar results concerning the blood circulation of the skin and the muscle during and after heating. According to previous studies, the change in the blood circulation of the skin and the muscle is considered to be mediated by many

central and peripheral factors, e.g., reflex via the sympathetic nervous system [21,27], nitric oxide which is a potent vasodilator substance [26] produced within the tendon by acupuncture or heating treatment. In a preliminary study with 7 young men, we observed that the temperature of the non-heated tendon slightly increased (+0.26 ± 0.35 °C, $p < 0.05$) at the end of heating, but afterwards did not change during the recovery period. Therefore, we may say that changes in the body or the non-heated tendon temperature are not related to the increase in THb of the non-heated tendon during the recovery period. However, it is unknown what the exact mechanism is for the increase in the blood volume of the non-treated tendon after removal of the needle (**Fig. 1c**) or the hot pack (**Fig. 3c**). Further investigations are needed to clarify the mechanism of this interesting phenomenon.

According to our recent study [18], THb and StO_2 of the treated Achilles tendon tended to return to the resting level soon after the "10 min" heating. As we expected, increases in THb and StO_2 at the end of heating in this study were obviously greater than those by the 10 min heating [18]. The larger increases in THb and StO_2 of the tendon caused a longer recovery time to the resting level after the completion of the 20 min heating treatment. In this sense, the present results during the recovery period after "20 min" heating had the same tendency as in our previous findings during corresponding period after "10 min" heating [18]. On the other hand, in a previous study [18] we found that the increases in THb and StO_2 during acupuncture remained constant for a long time after removal of the needle. The same results obtained in this study indicate unquestionably that acupuncture is superior to the hot pack in the long lasting effect after completion of the treatment, especially when compared with the previous study using 10 min heating [18].

In the present study, we applied the treatments to the right Achilles tendon to investigate blood circulation in both the left and right Achilles tendons. For acupuncture treatment, there were 2 different approaches of acupuncture treatment, i.e., inserting needles into specific acupuncture points which are distant from the site of symptom according to traditional oriental theories (remote acupuncture) and inserting needles directly into the symptomatic skin and muscle (dry needling). Although the point in the Achilles tendon into which the needle was inserted was not an acupuncture point in this study, the changes in the blood circulation in the treated tendon might be the benefit from dry needling and such improvement in the contralateral limb might be the benefit from remote acupuncture. Interestingly, the time courses of the changes in the blood circulation were different between the ipsilateral and conralateral limb in respond to the acupuncture treatment. These results suggest that both approaches of acupuncture treatment have therapeutic benefits but have a different mechanism, and cast a significant insight into the different approaches of acupuncture treatment and their applications. In a future study we need to investigate the effect of acupuncture depending on the acupuncture point.

In conclusion, the blood volume in the tendon for the non-treated sides gradually increased only after removal of the needle or the hot pack in addition to increases in the blood volume and oxygen saturation during the needle manipulation (acupuncture) or the hot pack (heating) for the treated tendon as in the previous study [18]. These results obtained from the healthy subjects suggest that blood circulation of the tendon can be improved by performing acupuncture or heating treatments to the contralateral healthy limb even if the injured tendon is in a cast. In a future study, we need to investigate the effects of the changes in blood circulation of the tendon on the healing of actual injured tendons.

Acknowledgements

This study was supported by a Grant-in-Aid for Young Scientists (A) (21680047 to K. Kubo) from Japan Society for the Promotion of Science.

References

1 *Akyurekli D, Gerig LH, Raaphorst GP.* Changes in muscle blood flow distribution during hyperthermia. Int J Hyperthermia 1997; 13: 481–496
2 *Astrup A, Simonsen L, Bulow J, Christensen NJ.* Measurement of forearm oxygen consumption: role of heating the contralateral hand. Am J Physiol 1988; 255: E572–E578
3 *Blaak EE, van Baak NA, Kempen KPG, Saris WHM.* Effect of hand heating by a warm air box on O2 consumption of the contralateral arm. J Appl Physiol 1992; 72: 2364–2368
4 *Chance B, Dait MT, Zhang C, Hamaoka T, Hagerman F.* Recovery from exercise-induced desaturation in the quadriceps muscles of elite competitive rowers. Am J Physiol 1992; 262: C766–C775
5 *Dollberg S, Atherton H, Hoath S.* Changes in skin blood flow over the foot with warming of the contralateral heel. Acta Paediatr 1998; 87: 416–418
6 *Draper DO, Harris ST, Schulthies S, Durrant E, Knight KL, Ricard M.* Hot-pack and 1-MHz ultrasound treatments have an additive effect on muscle temperature increase. J Athl Train 1998; 33: 21–24
7 *Ernst M, Mathew HM Lee.* Sympathetic vasomotor changes induced by manual and electrical acupuncture of the Hoku point visualized by thermography. Pain 1985; 21: 25–33
8 *Gimbi A, Casciello G, Di Cesare A, Dragoni S, Sorrenti D.* A controlled study on the effects of hyperthermia at 434 MHz and conventional ultrasound upon muscle injuries in sport. J Sports Med Phys Fitness 2001; 41: 521–527
9 *Giombini A, Di Cesare A, Casciello G, Sorrenti D, Dragoni S, Gabriele P.* Hyperthermia at 434 MHz in the treatment of overuse sport tendinopathies: a randomized controlled clinical trial. Int J Sports Med 2002; 23: 207–211
10 *Giombini A, Giovannini V, Di Cesare A, Pacetti P, Ichinoseki-Sekine N, Shiraishi M, Naito H, Maffulli N.* Hyperthermia induced by microwave diathermy in the management of muscle and tendon injuries. Br Med Bull 2007; 83: 379–396
11 *Harriss DJ, Atkinson G.* International Journal of Sports Medicine – Ethical Standards in Sports and Exercise Science Research. Int J Sports Med 2009; 30: 701–702
12 *Johnson JM, Brengelmann GL, Rowell LB.* Interactions between local and reflex influences on human forearm skin blood flow. J Appl Physiol 1976; 41: 826–831
13 *Kashiba H, Ueda Y.* Acupuncture to the skin induces release of substance P and calcitonin gene-related peptide from peripheral terminals of primary sensory neurons in the rat. Am J Clin Med 1991; 19: 189–197
14 *Kashima S.* Spectroscopic measurement of blood volume and its oxygenation in a small volume of tissue using red laser lights and differential calculation between two point detections. Optics Laser Technol 2003; 35: 485–489
15 *Kleinhenz J, Streitberger K, Windeler J, Gubbacher A, Mavridis G, Martin E.* Randomised clinical trial comparing the effects of acupuncture and a newly designed placebo needle in rotator cuff tendonitis. Pain 1999; 83: 235–241
16 *Kubo K, Ikebukuro T, Tsunoda N, Kanehisa H.* Changes in oxygen consumption of human muscle and tendon following repeat muscle contractions. Eur J Appl Physiol 2008; 104: 859–866
17 *Kubo K, Ikebukuro T, Tsunoda N, Kanehisa H.* Noninvasive measures of blood volume and oxygen saturation of human Achilles tendon by red laser lights. Acta Physiol 2008; 193: 257–264
18 *Kubo K, Yajima H, Takayama M, Ikebukuro T, Mizoguchi H, Takakura N.* Effects of acupuncture and heating on blood volume and oxygen saturation of human Achilles tendon in vivo. Eur J Appl Physiol 2010; 109: 545–550

19 *Maeda M*, *Kachi H*, *Ishibashi N*, *Oyama Z*, *Kitajima Y*. The effect of electrical acupuncture-stimulation therapy using thermography and plasma endothelin (ET-1) levels in patients with progressive systemic sclerosis (PSS). J Dermatol Sci 1998; 17: 151–155
20 *Marshall JM*, *Stone A*, *Johns EJ*. Analysis of the responses evoked in the cutaneous circulation of one hand by heating the contralateral hand. J Auton Nerv Syst 1991; 32: 91–100
21 *Mitchell JH*. Neural control of the circulation during exercise. Med Sci Sports Exerc 1990; 22: 141–154
22 *Moriyama T*. Microneurographic analysis of the effects of acupuncture stimulation on muscle nerve sympathetic activity in humans: excitation followed by inhibition. Nippon Seirigaku Zassi 1987; 49: 711–721 (in Japanese)
23 *Nagasaka T*, *Hirata K*, *Nunomura T*. Contribution of arteriovenous anastomoses to vasoconstriction induced by local heating of the human finger. Jpn J Physiol 1987; 37: 425–433
24 *Nishijo K*, *Mori H*, *Yoshikawa K*, *Yazawa K*. Decreased heart rate by acupuncture stimulation in human via facilitation of cardiac vagal activity and suppression of cardiac sympathetic nerve. Neurosci Lett 1997; 227: 165–168
25 *Ohsawa H*, *Okada K*, *Nishijo K*, *Sato Y*. Neural mechanism of depressor responses of arterial pressure elicited by acupuncture-like stimulation to a hindlimb in anethetized rats. J Auton Nerv Syst 1995; 51: 27–35
26 *Palmer RMJ*, *Ferrige AG*, *Moncada S*. Nitric oxide release accounts for the biological activity of endothelium-derived relaxing factor. Nature 1987; 327: 524–526
27 *Saito M*, *Naito M*, *Mano T*. Different responses in skin and muscle sympathetic nerve activity to static muscle contraction. J Appl Physiol 1990; 69: 2085–2090
28 *Sandberg M*, *Lundeberg T*, *Lindberg LG*, *Gerdle B*. Effects of acupuncture on skin and muscle blood flow in healthy subjects. Eur J Appl Physiol 2003; 90: 114–119
29 *Sato A*, *Sato Y*, *Shimura M*, *Uchida S*. Calcitonin generated peptide produces skeletal muscle vasodilation following antidromic stimulation of unmyelinated afferents in the dorsal roots in rats. Neurosci Lett 2000; 283: 137–140