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• Research Article

The anatomical study of the major signal points of the court-type Thai traditional massage on legs and their effects on blood flow and skin temperature

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ABSTRACT

OBJECTIVE: This study aims to investigate the relationship between major signal points (MaSPs) of the lower extremities used in court-type Thai traditional massage (CTTM) and the corresponding underlying anatomical structures, as well as to determine the short-term changes in blood flow and skin temperature of volunteers experiencing CTTM.

METHODS: MaSPs were identified and marked on cadavers before acrylic color was injected. The underlying structures marked with acrylic colors were observed and the anatomical structures were determined. Then, pressure was applied to each MaSP in human volunteers (lateral side of leg and medial side of leg) and blood flow on right dorsalis pedis artery was measured using duplex ultrasound while skin temperature changes were monitored using an infrared themographic camera.

RESULTS: Short-term changes in the blood flow parameters, volume flow and average velocity, compared to baseline ($P < 0.05$), were observed on MaSP of the lower extremity, ML4. Changes in the peak systolic velocity of the area ML5 were also observed relative to baseline. The skin temperature of two different MaSPs on the lateral side of leg (LL4 and LL5) and four on the medial side of leg (ML2, ML3, ML4 and ML5) was significantly increased ($P < 0.05$) at 1 min after pressure application.

CONCLUSION: This study established the clear correlation between the location of MaSP, as defined in CTTM, and the underlying anatomical structures. The effect of massage can stimulate skin blood flow because results showed increased skin temperature and blood flow characteristics. While these results were statistically significant, they may not be clinically relevant, as the present study focused on the immediate physiological effect of manipulation, rather than treatment effects. Thus, this study will serve as baseline data for further clinical studies in CTTM.

Keywords: complementary therapies; massage; cadaver; blood flow; skin temperature

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1 Introduction

Massage is the systemic manipulation of the body's soft tissue with the purpose of to enhancing health and promoting healing.[1] Although effects of different types of massages are reported in various scientific journals, only a few pertain to Thai traditional massage. In Thailand, there are two main types of traditional massages,[2] here referred to as popular type and court-type. Court-type Thai traditional massage (CTTM) gets its name from the traditional discipline reserved for members of the royal court. The main purpose of CTTM is treating ailments, while the popular type is used for relaxation. The CTTM technique specifies that only hands and thumbs are used to massage the body.[3] Despite its origins at court, CTTM is currently used widely in Thailand including hospitals, primary health care units and district hospitals. The application of pressure to the major signal points (MaSPs) to produce healing or alleviate ailments is at the heart of the massage treatment in CTTM.[4] Thai traditional practitioners believe that MaSP massage can decrease muscle tension, increase blood and lymphatic circulations and stimulate the nervous system.[2–4] There are 10 basic massage lines and 50 specific MaSPs distributed throughout the body, including the extremities, abdomen, head and neck.[3,4]

Studies have shown the clinical efficacy of massage in relieving pain and muscle tension.[5–8] Specifically, a randomized controlled trial demonstrated that CTTM was superior to standard physical therapy in relieving muscle tension, muscle spasm and increasing functional ability in stroke patients.[6] Massage has also been shown to affect blood circulation.[9–11] Chenpanich et al.[12] demonstrated that CTTM was able to significantly decrease blood pressure, as well as increase local skin temperature (ST) in the upper extremities of human volunteers. Moreover, the ST in the present study was detected by infrared camera technology, which can reliably localize changes in ST.[13] An additional study also showed that even the isolated application of pressure on MaSPs of the neck, shoulder and arm was able to increase blood circulation significantly.[14] This suggests that MaSPs may have anatomical correlations with muscles and blood vessels that mediate the effect of massage on blood flow (BF), blood volume and ST of the manipulated areas. However, MaSP manipulation of the lower extremities differs substantially from that of the upper extremities in terms of the larger body surface and blood supplies, position of the practitioner as well as the force applied. Thus, in order to bridge the knowledge gap and document the anatomical and physical effects of CTTM, we have undertaken a similar study for the lower extremities. The objective of this study is to characterize the correlation of the underlying anatomical structures with each MaSP. In addition, this study aims to describe and compare the ST and BF changes in the lower extremities when each MaSP is manipulated.

2 Materials and methods

2.1 Study design

This study was approved by the ethical committee of the Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand. There are two parts to the study method (Figure 1). The first part relates to the study of anatomical relationship of the MaSPs in the lower extremities using embalmed cadavers and is similar to the method described by Plakornkul et al.[14] The second part of the study relates to measuring BF and ST changes in healthy volunteers.

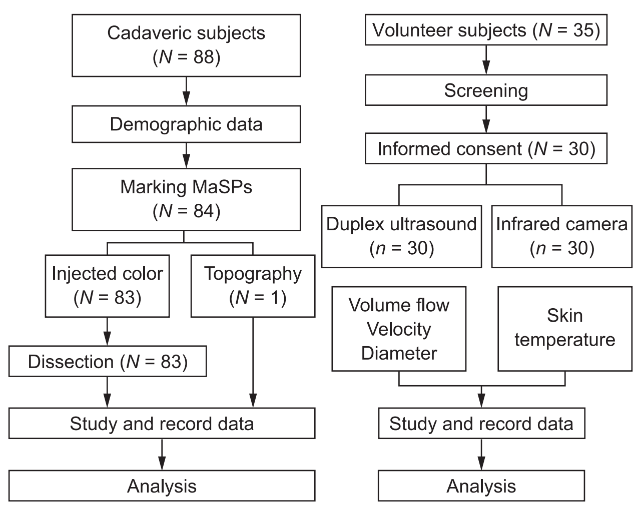

Figure 1 Study flowchart
MaSPs: major signal points.

2.2 Participants

2.2.1 Cadaveric specimens

The sample size needed to demonstrate statistical correlations among MaSPs and anatomical markers was not calculated. Instead, all of the embalmed cadavers intended for the use of medical students during the year 2012–2013, with no evidence of previous injury, deformity or prior surgery on the lower extremities, were included. Cadavers donated to the Department of

Anatomy, Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand, were from individuals who signed body donation consent forms prior to their deaths. They were preserved using standard embalming techniques.

2.2.2 Volunteer subjects

Healthy volunteers (n = 30), comprised of 15 males and 15 females, were used for ST and BF studies. Sample size was calculated from a pilot trial showing changes in mean blood velocity before and after pressure application of (17.42 ± 28.71) mL/min. Using test significance level of 0.05, a power = 80% and effect size of 0.607, the estimated sample size was 24. The same pilot trial was done measuring ST changes, and showed a mean difference of (0.69 ± 0.82) °C. Using test significance level = 0.05, power = 80% and effect size = 0.84, the calculated sample size was 14. Therefore, in order to ensure sufficiently significant result, we chose the larger sample size of 24.

Healthy volunteer subjects were students or staff of the Faculty of Medicine Siriraj Hospital, Mahidol University. All were required to satisfy the following criteria: (a) aged 18–25 years; (b) body mass index between 18 and 23 kg/m^2; (c) exercise < 5 times/week and not an active athlete; (d) nonsmoker and nonalcoholic; (e) no history of trauma, fracture, surgery or arthritis of the lower extremities; (f) not suffering from skin rash or other dermatological condition on the lower extremities; (g) not diagnosed with a communicable disease; (h) no underlying neuropathy, musculoskeletal or cardiovascular disease; (i) no history of hypertension or diabetes; (j) not febrile (body temperature < 38.5 °C); (k) not pregnant or menstruating (only female). All participants were required to read and sign informed consent prior to engaging in any study procedures. The study was performed at the Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand.

2.3 Intervention and measurement

2.3.1 Cadaveric specimens

All cadavers were checked for anatomical intactness. Then map pins were used to mark the MaSPs 1 to 5 on lateral side of the leg (MaSP-LL1 to MaSP-LL5) and the medial side of the leg (MaSP-ML1 to MaSP-ML5) by three licensed applied Thai traditional medical (ATM) practitioners, who were experts in CTTM from the Center of Applied Thai Traditional Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand. The pin placement was agreed upon by the 3 practitioners before the experiment in order to minimize variability among practitioners. Subsequently, pin locations were injected with acrylic color, using a hypodermic syringe (18.0 inches × 1.5 inches). Figure 2 illustrates the underlying anatomical locations of MaSPs, as marked by pins. Correlations between acrylic markers and the underlying anatomical structures were determined after the cadavers had been dissected by medical students. Areas marked with acrylic colors were observed using a circular ring with a diameter of 1 inch or 1.5 inches as illustrated in Figure 3.

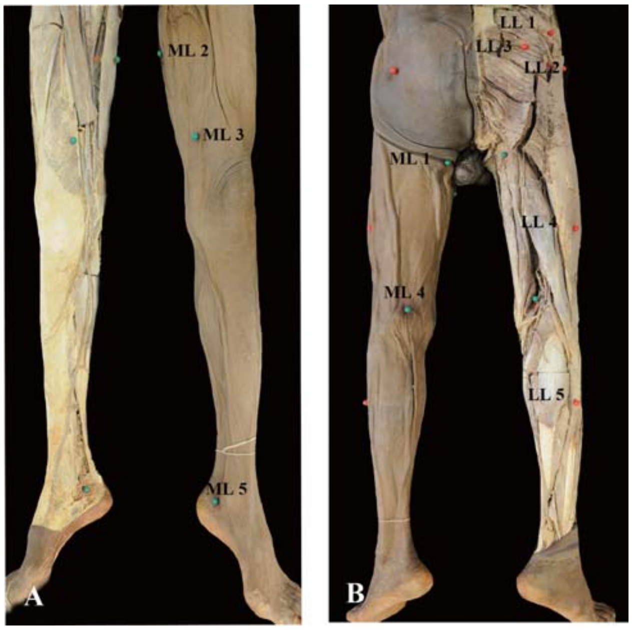

Figure 2 The major signal points of the leg on cadaver
Major signal points 1 to 5 on lateral side of leg (MaSP-LL1 to MaSP-LL5) and medial side of leg (MaSP-ML1 to MaSP-ML5). A: anterior view; B: posterior view.

Figure 3 Instruments used for studying on cadaveric specimens
A: pin (18.0 inches × 1.5 inches); B: map pins; C: ring diameter 1 inch or 1.5 inches; D: hypodermic syringe; E: instrument for dissection.

2.3.2 Volunteer subjects

The locations of 10 MaSPs are shown in Figure 4 on one of the volunteers. Pressure application to all MaSPs was performed by a single practitioner, who also participated in the cadaver experiment. As specified by CTTM technique, both thumbs were used to apply pressure in 3 stages, initiation, accentuation and steady, on each MaSP, over a 30-second period.[2,3] After 30 s of applying pressure on each MaSP, the thumbs were released from the point and the measurements were performed.

BF studies on volunteers were performed at the Division of Vascular Surgery Unit, Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand. An ATM practitioner massaged the MaSP-ML1 to -ML5 (Figure 4), while a technician measured BF continuously, from before MaSP manipulation to 5 min after completion of the massage, using an ultrasound machine designed to make precise BF measurements (LOGIQ E9; GE Healthcare, Milwaukee, Wis., USA). Using a digital mobile sphygmomanometer on the left arm, two sets of blood pressure and heart rate measurements were taken: one after a 15-minute rest period before pressure application, and a second after the completion of all 5 MaSP manipulations.

Blood volume, velocity and the vessel diameter measurements were conducted on the left dorsalis pedis artery (Figure 5). Only the 5 MaSPs which corresponded to the arteries of the lower extremities were used when measuring BF. The blood volume was automatically calculated by using vessel diameter. Because a previously performed pilot study determined that BF and ST effects were not observable after 5 min, we rationalized that our measurements should occur at baseline ($T_{baseline}$), immediately after pressure release (T_1), 1 min after pressure release (T_2), 3 min after pressure release (T_3) and 5 min after pressure release (T_4) for each MaSP. A 5-minute rest period was observed before applying pressure to the next MaSP.

ST was recorded by a infrared thermographic camera (TVS-500; Nippon Avionics, Japan). ST of MaSP-ML2 to ML5 and MaSP-LL4 and MaSP-LL5 was measured after manipulation by the ATM practitioner. Nonetheless, the ST of MaSP-ML1, MaSP-LL1, MaSP-LL2 and MaSP-LL3 was not shown due to the subjects clothing. The room was controlled for illumination and kept at a constant temperature of 25 ºC. Thermography Studio 2007 (version 4.8) was used to extract temperatures from the thermal images. Tympanic temperature of the participants was measured after a 15-minute resting period and before the experiment began. The STs were measured at $T_{baseline}$, T_1, T_2, T_3 and T_4. A 5-minute rest period was observed before applying pressure to the next MaSP.

2.4 Statistical analysis

SPSS for Windows (SPSS Inc, Version 18.0; Chicago, IL, USA) was used to analyze the data. Descriptive data includes percent of anatomical correlation to each MaSP. Volume and mean velocity of BF were tested after natural logarithm transformation because data were not normally distributed. Two-way repeated measures analysis of variance with Bonferroni's method for adjusted multiple comparisons was used to compare the changing volume and velocity of BF, diameter of left dorsalis pedis and ST in each of the MaSP. These values were compared to baseline.

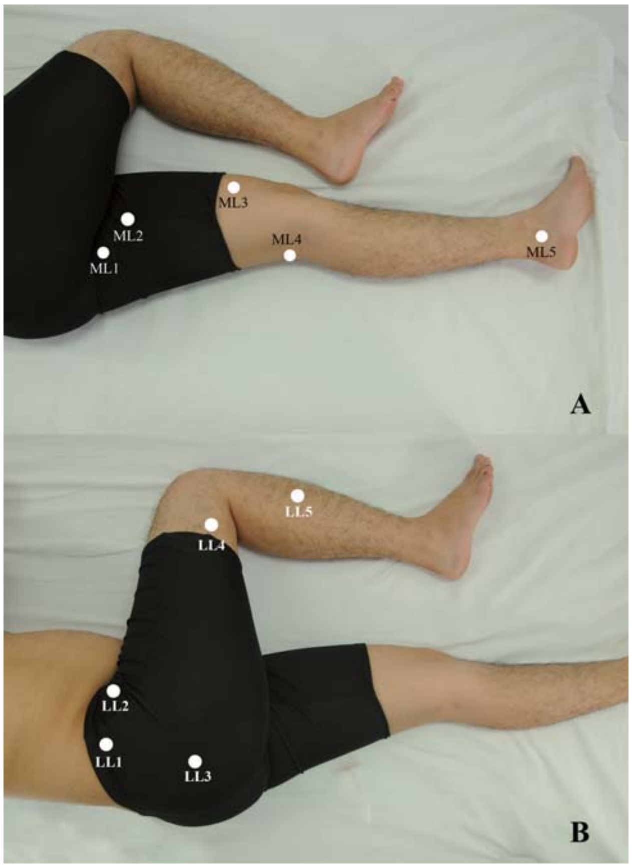

Figure 4 The major signal points of the leg on human

A: major signal points 1 to 5 on medial side of leg (MaSP-ML1 to MaSP-ML5); B: major signal points 1 to 5 on lateral side of leg (MaSP-LL1 to MaSP-LL5).

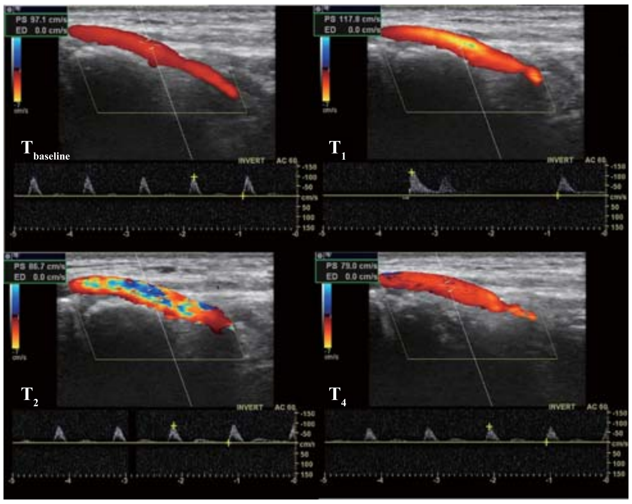

Figure 5 Measurement of blood flow before and after pressure application at baseline ($T_{baseline}$), immediately after pressure release (T_1), 1 min after pressure release (T_2) and 5 min after pressure release (T_4) on the MaSP-ML3 at dorsalis pedis artery

3 Results

3.1 Cadaveric specimens

A total of 84 embalmed cadavers (32 females and 52 males) were included in this study, out of the 88 available. The median age was 72 years (range 21–99 years). A high degree of anatomical correlation was observed for most MaSPs, except for MaSP-ML1–ML2, where 2 adjacent muscles were identified. Detailed correlation data can be found in Table 1.

Table 1 Anatomical relation on major signal points on lateral side of leg (MaSP-LL1 to MaSP-LL5) and medial side of leg (MaSP-ML1 to MaSP-ML5) (N = 84)

Structure	MaSP-LL1	MaSP-LL2	MaSP-LL3	MaSP-LL4	MaSP-LL5
Subcutaneous	Subcostal cutaneous nerve (100%)	Subcostal cutaneous nerve (100%)	Dorsal rami L1–L3 (100%)	Lateral cutaneous nerve of thigh (100%)	Lateral sural cutaneous nerve (100%)
Muscle	Gluteus medius (100%) Gluteus minimus (100%)	Iliotibial tract (100%) Tensor fascia latae (100%) Gluteus medius (100%)	Gluteus maximus (100%) Pirifomis (100%) Superior and inferior gemellus (77.38%) Obturator internus (77.38%)	Iliotibial tract (100%) Vastus lateralis (100%) Vastus intermedius (100%)	Crural fascia (100%) Peroneus longus (100%)
Vessel	Superior gluteal artery (98.81%)				
Nerve	Superior gluteal (98.81%)				Superficial peroneal (100%)
Bone	Ilium part of pelvic (100%)	Ilium part of pelvic (100%)	Ischium part of pelvic, capsular ligament of hip joint and neck of femur (100%)	Lateral side of femur (100%)	Fibular bone (100%)

Structure	MaSP-ML1	MaSP-ML2	MaSP-ML3	MaSP-ML4	MaSP-ML5
Subcutaneous	Posterior cutaneous nerve of thigh (100%)	Cutaneous branch of obturator nerve (100%)	Med. cutaneous nerve of thigh (100%)	Posterior cutaneous nerve of thigh (100%)	Saphenous nerve (100%)
Muscle	Semitendinosus (100%) Semimembranosus (100%) Biceps femoris (long head) (100%) Adductor maximus (ham part) (52.38%)	Gracilis (100%) Adductor magnus (82.14%) Adductor longus (47.61%) Vastus medialis (100%)	Vastus medialis (100%)	Popliteal fascia (100%)	Flexor retinaculum (100%) Flexor halluces longus (100%)
Vessel		Femoral vessel (100%)	Femoral vessel (Adductor canal) (85.71%) Descending genicular artery (100%)	Popliteal vessel (100%)	Posterior tibial artery (100%)
Nerve		Anterior branch of obturator nerve (100%) Posterior branch of obturator nerve (82.14%) Saphenous nerve (100%)	Nerve to vastusmedialis (76.19%) Saphenous nerve (Adductor canal) (100%)	Tibial nerve (100%)	Tibial nerve or medial and lateral plantar nerve (100%)
Bone	Shaft of femur (100%)	Shaft of femur (100%)	Shaft of femur (100%)	Popliteal surface of femur (100%)	Talus bone (100%)

3.2 Volunteer subjects

Thirty volunteer subjects (15 male and 15 female) were enrolled in this study. The demographic data and physical characteristic of participants are shown in Table 2.

Table 2 Physical characteristics of participants

Factor	N	Values	
		Mean	Standard deviation
Age (year)	30	22.20	2.02
Weight (kg)	30	57.97	7.11
Height (cm)	30	166.50	6.89
Body mass index (kg/m^2)	30	20.98	1.94
Systolic pressure (mmHg)	30	106.10	8.96
Diastolic pressure (mmHg)	30	59.77	8.34
Heart rate (beat/min)	30	72.43	11.34
Temperature (°C)	30	36.73	0.47

The volume and velocity of BF showed a similar pattern of change for all MaSPs: both values decreased with pressure application and increased immediately after pressure release (Figure 5). However, both volume and velocity of BF at MaSP-ML1 and -ML2 did not return to baseline values, while MaSP-ML3 through MsSP-ML5 exceeded their baseline values. The vessel diameter showed no statistically significant changes (Figure 6). ST of MaSPs significantly increased immediately after pressure application (0.2–0.4 °C on the MaSP-LL4 and MaSP-LL5 and 0.2–0.7 °C on the MaSP-ML2 through MaSP-ML5). ST on the MaSP-ML4 appeared as changed skin color in the thermal images, as seen in Figure 7. The color of area 1 in Figure 7B, C, D and E revealed higher temperature than that was present in Figure 7A. ST on MaSP-ML2 through ML5 and MaSP-LL4 and LL5 slowly decreased, but remained higher than baseline at 5 min after pressure release (Figure 8).

4 Discussion

This study is the first to report both the anatomical correlation of MaSP and the effects of MaSP massage on BF and ST in the lower extremities. Such correlation helps substantiate the traditional belief that pressure on the MaSP can affect nerves and control the distribution of blood and heat to parts of the body.[2]

The fluctuation in BF of ML1-5 at different time points confirms the effect of MaSP manipulation on circulation. In our study, we measured BF from the dorsalis pedis artery, which is the terminal branch of femoral artery. Therefore, applying pressure on the MaSP proximal

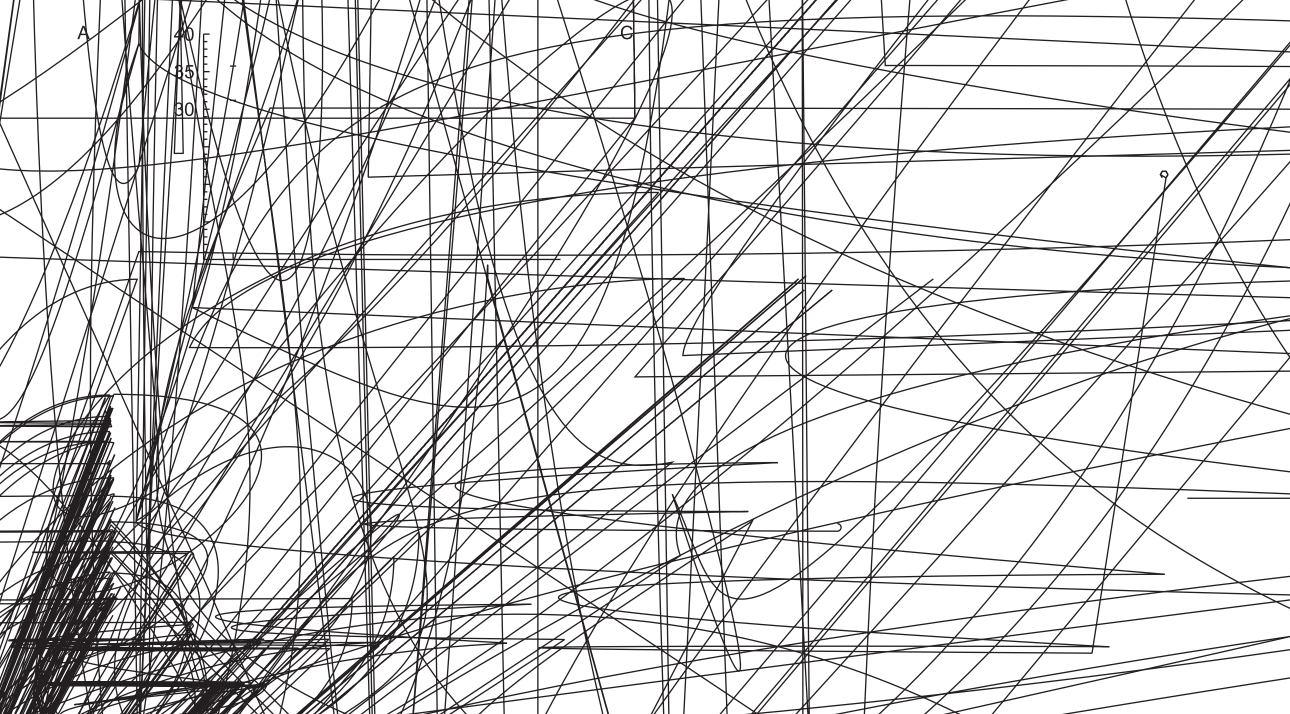

Figure 5 Changes in blood flow of the dorsalis pedis which correspond to the major signal points on medial side of leg (MaSP-ML1 to ML5) in each point compared with baseline (N = 30)

A: volume flow (antilogarithm of mean and standard deviation); B: average mean velocity (antilogarithm of mean and standard deviation); C: diameter of dorsalis pedis; D: peak systolic velocity.

*Statistical significant at P < 0.05 compared with $T_{baseline}$ on MaSP-ML1 (*), MaSP-ML2 (△), MaSP-ML3 (▲), MaSP-ML4 (□), and MaSP-ML5 (■).

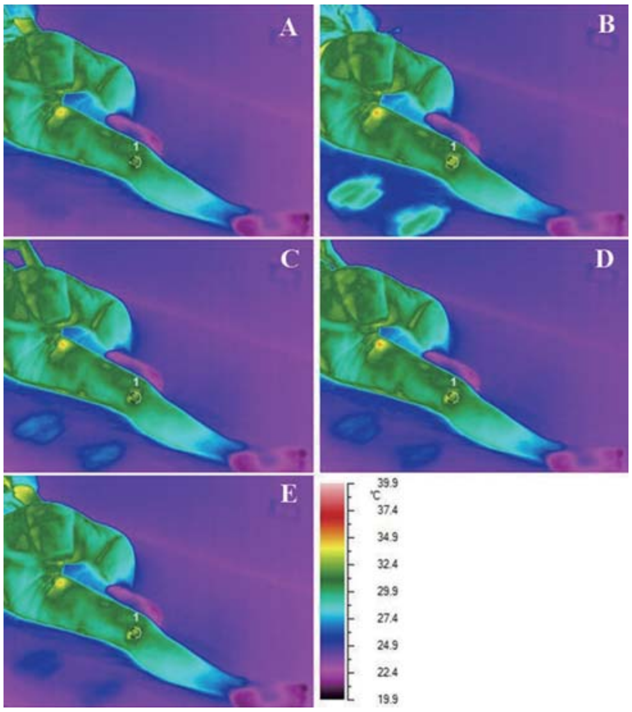

Figure 7 Infrared thermography image of skin temperature at major signal point on medial side of left leg

Area 1 represent the area of the MaSP-ML4. (A) $T_{baseline}$, (B) T_1, (C) T_2, (D) T_3, and (E) T_4.

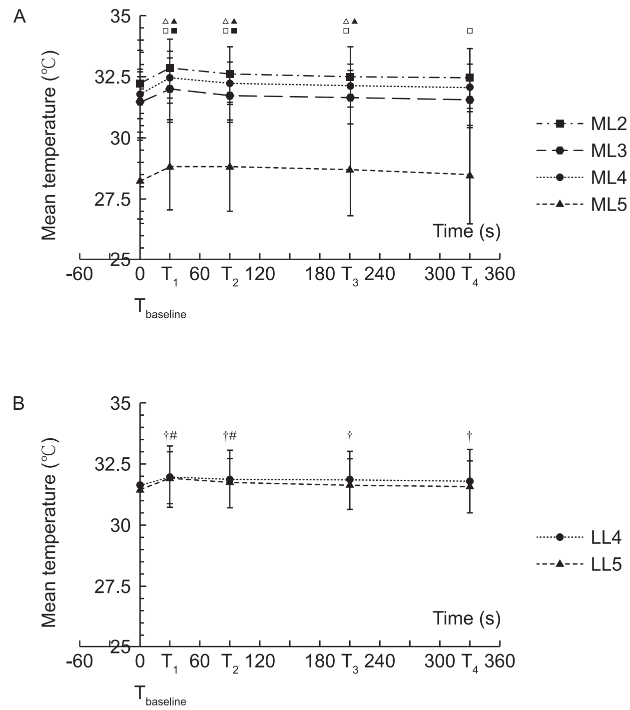

Figure 8 Changes in skin temperture on the major signal points in each point compared with baseline (N = 30)

A: The major signal points on medial side of leg (MaSP-ML2 to ML5); B: The major signal points on lateral side of leg (MaSP-LL4 and -LL5). Statistical significant at P < 0.05 compared with $T_{baseline}$ on MaSP-ML2 (△), MaSP-ML3 (▲), MaSP-ML4 (□), MaSP-ML5 (■), MaSP-LL4 (†), and MaSP-LL5 (#).

to the dorsalis pedis artery can cause BF alteration. By taking into account the ambient temperature,[15] circadian rhythm and time of day, this study attempts to control for factors which can affect body and ST.[16] Other published literature also confirmed the effect of massage on ST. Drust et al.[17] examined the effect of massage and ultrasound on intramuscular temperature in the vastus lateralis muscle in humans. Changes in muscle temperature at 1.5 and 2.5 cm were significantly greater following massage than following ultrasound (P < 0.002). Chenpanich et al.[12] studied Thai traditional massage and showed that an increase in temperature occur red in both feet even though only the right leg was massaged. Although using different massage protocols, these results still illustrated the effect of massage on increasing ST. Higher changes in ST observed in our study are attributed to the fact that MaSPs located on the ML are correlated with blood vessels and yield higher ST, while points on the lateral side are not. These observed changes in STs are related to study duration. To ascertain the true effect of MaSP pressure in future studies, as well as mimic CTTM practice, basic massage maneuvers should be added before MaSP pressures are done. Although most BF studies by Doppler ultrasound reporting V_{max}, V_{mean} and BF use the femoral artery,[18–20] this study uses the dorsalis pedis instead. This is because CTTM position requires that the patient lies on his side, making femoral artery measurements impossible. On the other hand, measuring BF changes at the most distal positions reaffirms CTTM's theory that manipulation of MaSPs should lead to improved BF distal to the points of manipulation.

In this study, MaSP-ML2 is shown to be near the femoral artery, while MaSP-ML4 corresponds to the location of the popliteal artery. CTTM indicates that these MaSPs are among the key points for treatment of lower back pain and diseases related to the lower extremities.[4] However, it is worth noting that the normal CTTM protocol usually involves massages that cover both the basic and the specific MaSPs. Thus, when each of these MaSPs is manipulated separately, the results may differ from the protocol followed in the present study. Therefore, further studies of ST and BF changes within the context of the complete CTTM treatment protocol are needed in order to establish their true clinical significance.

Results from a similar study of BF and ST changes after MaSP manipulation of the upper extremities found that both parameters changed in a pattern similar to the present work.[14] Their work showed that ST increased immediately after pressure application on the MaSP and then slowly decreased. MaSPs which were supplied by the brachial and radial arteries had significant and sustained

BF changes during the first 30s of pressure. On the contrary, similarly located MaSPs of the lower extremities in our study showed much more sustained BF changes. In addition, manipulation of the laterally located MaSPs of the upper extremity corresponded with significant changes in STs of all areas, while medially located MaSPs resulted in only 2 areas of ST changes.[14] In contrast, our study found significant changes in STs for both medially and laterally located MaSPs of the leg. Over all, MaSP manipulation resulted in similar patterns of ST and BF changes in both the upper and lower extremities. However, the degree of changes in ST was much more pronounced in the lower extremities. Regardless, these findings reaffirmed the belief that MaSP manipulation results in increased distribution of blood and warmth to distal areas, and that is the heart of CTTM practice.

The anatomical study of the MaSP on cadavers has many limitations associated with the morphology of cadavers and indistinct surface marking. However, the use of more experienced ATM practitioners can minimize errors. In addition, the wide age range of the cadavers may affect their anatomical landmarks and anatomical variations among individual cadavers.

5 Conclusions

This study establishes the clear association between MaSPs, as defined in CTTM, and the underlying anatomical structures. Validation of CTTM techniques using measurable outcomes, such as landmarks, ST and BF changes, helps to document and validate traditional knowledge. This will serve as baseline data for further clinical studies of CTTM to confirm the traditional CTTM theory.

6 Funding

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8 Conflict of interest

The authors declare that there is not any conflict of interests.

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