Exploration of the Pressing Frequency of '按之则热气至 (Pressing Brings Hot Qi)' Using Infrared Thermal Imaging Technology: A Postprint on Thermal Effect Mechanisms

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Abstract

Background An increasing number of objective measurement methods exist for the Tuina dose-effect relationship, yet studies combining infrared thermography technology with the Tuina dose-effect relationship remain scarce. Objective To provide evidence for the application of infrared thermography technology in investigating the Tuina dose-effect relationship by comparing changes in temperature values, muscle tension, and pressure pain thresholds in the treatment area under different frequencies of the overlapping palm pressing method (3, 5, and 7 presses). Methods From June 17 to December 24, 2021, 18 patients with thoracic facet joint disorder (lesion segment at T3–T4) were recruited from the Department of Tuina, Guangdong Provincial Hospital of Traditional Chinese Medicine (Dade Road Main Branch). Patients were divided into a 7-press group (n=6), a 5-press group (n=6), and a 3-press group (n=6), and received overlapping palm pressing method treatment with 7, 5, and 3 presses, respectively. An infrared thermal imaging device was used to obtain whole-body infrared thermograms of patients and extract average temperature values from the lesion area; a soft tissue tension testing and analysis system was employed to measure muscle tension of the erector spinae muscle beside the affected thoracic vertebrae; and a pain threshold measurement device was utilized to measure pressure pain thresholds at body surface areas beside the spinous processes of the affected thoracic vertebrae. Results Post-intervention temperature values at T3 spinous process 0.5 cun lateral to the right (T3 R) and T4 spinous process 0.5 cun lateral to the right (T4 R) in the 3-press group were lower than pre-intervention values ($P<0.05$). Post-intervention comparisons among the three groups revealed statistically significant differences in muscle tension under 0.2 kg force at T3 spinous process 0.5 cun lateral to the left (T3 L), muscle tension under 0.2 kg force at T3 R,

muscle tension under 0.2 kg force at T4 spinous process 0.5 cun lateral to the left (T4 L), muscle tension under 0.5 kg force at T4 L, muscle tension under 0.8 kg force at T4 L, muscle tension under 0.2 kg force at T4 R, and muscle tension under 0.5 kg force at T4 R ($P<0.05$). Post-intervention pressure pain thresholds at T3 L, T3 R, T4 L, and T4 R in the 3-press group were lower than pre-intervention values ($P<0.05$). Post-intervention pressure pain thresholds at T3 L and T3 R in the 7-press group were lower than pre-intervention values ($P<0.05$). No adverse events occurred in any of the three groups during treatment. Conclusion Fewer presses may yield better therapeutic efficacy. Infrared thermography technology as a measurement method for the Tuina dose-effect relationship still requires further investigation. The issues identified in this study may provide further research directions for the relationship between infrared thermography and Tuina.

Full Text

Preamble

Warm Qi Arrives after Tuina: Dose-effect Association between Number of Tuina and Warming Effect Measured Using Infrared Thermal Imaging

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Abstract

Background: An increasing number of objective measurements are used to explore the dose-effect relationship of Tuina, but infrared thermal imaging has been rarely employed in such research. **Objective:** To compare temperature, muscle tone, and pain threshold changes in the lesion area following different numbers of cross-palm pressing manipulations (3, 5, and 7 times) using infrared thermal imaging, thereby providing evidence for applying this technology to study Tuina's dose-effect relationship.

Methods: From June 17 to December 24, 2021, 18 patients with thoracic facet joint disorder (affected segments at T3-T4) were recruited from the Tuina Department of Guangdong Provincial Hospital of Chinese Medicine (Dade Road Main Hospital). Patients were divided into three groups receiving 7, 5, or 3 presses respectively (n=6 each). Infrared thermal imaging was used to obtain full-body thermograms and extract mean temperature values from lesion areas. Muscle tone of the erector spinae adjacent to affected vertebrae was measured using a soft tissue tension analysis system, and pressure pain thresholds at paravertebral sites were measured using a pain threshold analyzer.

Results: In the 3-press group, post-intervention temperature values at 0.5 inch right of T3 spinous process (T3 R) and 0.5 inch right of T4 spinous process (T4 R) were significantly lower than pre-intervention values ($P<0.05$). After intervention, statistically significant differences among the three groups were observed in muscle tension at multiple sites: T3 left (T3 L) at 0.2 kg, T3 R at 0.2 kg, T4 L at 0.2 kg, 0.5 kg, and 0.8 kg, and T4 R at 0.2 kg and 0.5 kg ($P<0.05$). The 3-press group showed decreased pressure pain thresholds at T3 L, T3 R, T4 L, and T4 R post-intervention ($P<0.05$), while the 7-press group showed decreases at T3 L and T3 R ($P<0.05$). No adverse events occurred during treatment.

Conclusion: Fewer presses may produce better clinical outcomes. Further research is needed to explore infrared thermal imaging as a measurement tool for Tuina's dose-effect relationship. This study provides valuable ideas for future investigations combining infrared thermal imaging with Tuina therapy.

Keywords: Tui Na therapy; Infrared thermal imaging; Thermal effect; Manual technique; Frequency

Introduction

Thoracic facet joints are formed by the superior and inferior articular processes of adjacent vertebrae and surrounding soft tissues, possessing joint capsules and synovial membranes with hyaline cartilage-covered articular surfaces and synovial fluid within the joint space [1]. When external forces act on the thoracic spine, facet joints may undergo slight subluxation under negative pressure, with synovial membranes becoming entrapped within the subluxated joint cavity,

resulting in pain and functional impairment [2]. Chronic recurrent episodes can affect normal spinal function and lead to varying degrees of degenerative changes within the facet joints [3]. Internationally, despite exponential growth in treatment options, indications and medical necessity for interventions, particularly for facet joint pain, remain controversial [4]. In China, thoracic facet joint disorders fall under the category of "bone misalignment and tendon displacement" in traditional Chinese medicine. Professor Lin Yingqiang, founder of the Lingnan Lin's Bone-Setting Tuina School, advocated the concept of "medicine and martial arts sharing the same origin." Professor Wu Shan, a successor of Lin's academic thought, modified the slow thrusting technique into a low-velocity, low-amplitude manipulation commonly using 3-7 presses as the standard range for thoracic facet joint reduction [5].

The *Suwen· Jutong Lun* states: "When cold qi lodges in the back-shu vessels, the blood vessels congeal; when congealed, blood becomes deficient; when deficient, pain occurs. The shu points connect to the heart, thus causing referred pain. Pressing brings warm qi; when warm qi arrives, pain ceases." This elucidates the mechanism of pressing techniques, explaining their qi-moving, blood-activating, and cold-dispersing effects. Weerapong et al. [6] proposed that mechanical pressure from manual therapy may increase blood flow by elevating arteriolar pressure, while friction generated by manipulation raises skin temperature. Manual therapy exerts effects not only through biomechanics but also by increasing local tissue temperature, functioning from a biothermal physics perspective [7]. Infrared thermography (IRT) operates by using scanners to receive thermal radiation signals from the human body, with computers reconstructing metabolic intensity distribution maps corresponding to examined areas [8], thereby assisting clinicians in quantitative assessment [9]. This technology holds significant reference value for measuring the "warm qi arrival" phenomenon. Despite the profound influence of Lin's Bone-Setting Tuina School, few studies have employed infrared tomography systems to deeply investigate the relationship between stimulation dosage and therapeutic efficacy. Quantitative efficacy research informs technique standardization, while infrared systems assist clinical outcome evaluation—combining both approaches offers new insights for quantifying Tuina research.

Currently, few studies examine Tuina's dose-effect relationship through temperature values. Therefore, this study utilized infrared thermal imaging and MFF multi-point thin-film pressure measurement instruments. Based on Song Qiliang et al.'s research [10] showing higher prevalence of T3-T4 segment facet joint disorders, we selected volunteers with lesions at T3-T4. Eighteen patients with thoracic facet joint disorders received different frequencies of cross-palm pressing, with pre- and post-treatment thermograms of lesion areas collected and analyzed alongside muscle tone and pain thresholds to explore the biomechanical patterns of this technique.

Methods

Study Design and Participants

Strictly following inclusion and exclusion criteria, 18 patients with thoracic facet joint disorder were recruited from the Tuina Department of Guangdong Provincial Hospital of Chinese Medicine (Dade Road Main Hospital) between June 17 and December 24, 2021. The trial was conducted at the hospital's Tuina Department, Preventive Medicine Center, and Guangdong Gaoshang Medical Imaging Center. This study was approved by the Ethics Committee of Guangdong Provincial Hospital of Chinese Medicine (Ethics No.: YF2021-110-01), and all participants signed informed consent prior to enrollment.

Diagnostic, Inclusion, and Exclusion Criteria

Diagnostic Criteria for Thoracic Facet Joint Disorder were established according to *Tuina Science* (2nd edition) [12]:

Clinical Manifestations: (1) Pain following acute or chronic thoracic back injury, with pulling pain at the lesion site during head, neck, and chest movement, possibly accompanied by anterior chest, neck, shoulder, and upper limb pain, difficulty turning over, and symptoms of nerve, sympathetic, or vertebral artery compression such as dizziness, headache, chest tightness, and palpitations; (2) Physical examination revealing deviated thoracic spinous processes, vertebral tenderness, palpable cord-like tense or spasmodic paravertebral muscle bundles, and in chronic cases, palpable subcutaneous nodules with adhesions or hyperplastic changes; (3) Some patients may exhibit referred pain in viscera corresponding to the affected spinal level or symptoms in viscera innervated by the affected thoracic nerve segments.

Routine Signs: (1) Deviation of spinous processes at affected spinal segments, appearing as unilateral prominence with contralateral emptiness; (2) Significant tenderness at posterior joint sites of affected spinal segments, mostly unilateral, occasionally bilateral.

Imaging Findings: (1) Thoracic X-ray may show spinous process deviation >1 mm or degenerative changes such as vertebral endplate and facet joint hyperostosis; (2) X-ray can exclude fractures and other bone lesions; (3) Severe cases may show scoliosis and spinous process deviation.

Inclusion Criteria: (1) Meet diagnostic criteria for thoracic facet joint disorder; (2) Age 18-50 years, any gender; (3) Lesion at T3-T4 segments; (4) Chronic course >3 months [13]; (5) Visual Analogue Scale (VAS) score 5-7 [14-15]; (6) No organic disease, psychiatric history, familial genetic disease, or traumatic disease; (7) High compliance; (8) Voluntary participation with signed informed consent.

Exclusion Criteria: (1) Intolerance to manual therapy; (2) Thoracic scoliosis (Cobb angle >20°) [13], osteoporosis, vertebral fracture, or spinal surgery his-

tory; (3) Severe cardiovascular, cerebrovascular, digestive, respiratory, urinary, or hematological diseases; (4) Pregnancy or lactation.

Withdrawal Criteria: (1) Failure to complete the protocol after enrollment; (2) Voluntary withdrawal or refusal to participate in relevant examinations; (3) Active withdrawal of informed consent.

Termination Criteria: (1) Severe adverse events during treatment; (2) Emergence of other diseases requiring urgent management that preclude continued participation.

Materials

Equipment: MFF multi-point thin-film measurement instrument (Model 401 pressure-sensitive thin-film sensor: thickness 0.2 mm, length 67 mm, width 33 mm, sensing area diameter 25.4 mm, Shanghai Yicheng Testing Equipment Co., Ltd.); Pain threshold analyzer (Model YT-10C, developed by Chinese Academy of Sciences and Tianjin Mingtong Century Technology Co., Ltd.); Infrared thermal imager (Thermal Tomography System, Model TSI-2000); Soft tissue tension analysis system (Model JZL-III, Tianjin Mingtong Century Technology Co., Ltd.).

Intervention

Grouping: Based on internal control methods [16] and clinical practice, the exposure variable (number of presses) was treated as a quantitative variable divided into different levels, with the lowest level as control. Clinically, audible joint release typically occurs at 3, 5, or 7 presses, with other frequencies being rare. Therefore, groups were defined as: 7-press group, 5-press group, and 3-press group.

Imaging Examination: Before the formal trial, patients underwent anteroposterior and lateral thoracic radiography at Guangdong Gaoshang Medical Imaging Diagnostic Center using Suzhou Fuji Film Imaging X-ray equipment (75 kV, 320 mAs).

Treatment Method: Cross-palm pressing manipulation was performed with patients in prone position, head turned to the affected side, arms naturally placed at sides. The practitioner stood beside the patient, placed overlapped palms on the affected thoracic vertebrae (T3-T4), instructed deep inhalation, then applied downward pressure with “cun jin” (precise force) at end-exhalation. The procedure produced audible “clicking” sounds or sensation of vertebral movement. Slow thrusting technique is shown in [Figure 1: see original paper]. Each group received different press counts.

Outcome Measures

Primary outcomes included infrared thermal imaging temperature values, pressure pain thresholds, and muscle tone.

Temperature Change (t): Full-body infrared thermograms were obtained to extract mean temperature values from the lesion area (between T3-T4 vertebrae, within scapular lines) and at sites 0.5 inch lateral to T3 and T4 spinous processes.

Pressure Pain Threshold: The pain threshold analyzer applied mechanical stimulation to designated sites, starting from minimal force and gradually increasing until the patient perceived pain, recorded as the pain threshold value.

Muscle Tone: Soft tissue tension analysis system measured muscle tone of erector spinae adjacent to affected thoracic vertebrae.

Safety Evaluation: Adverse events including soft tissue injury, skin damage/bruising, pain, fracture/dislocation, and spinal cord injury were monitored.

Statistical Analysis

All data were analyzed using SPSS 22.0 (IBM Corporation, USA). Normally distributed continuous data were expressed as ($\bar{x}\pm s$), compared among groups using ANOVA and within groups using paired t-tests. Non-normally distributed data were expressed as $M(P_{25},P_{75})$, compared among groups using rank-sum tests and within groups using paired rank-sum tests. Categorical data were expressed as relative numbers and compared using ^{2} tests. Significance level was set at bilateral α=0.05.

Results

Participant Flow and Baseline Characteristics

During recruitment, 18 patients meeting inclusion criteria were enrolled and divided into three groups (6 per group): 7-press, 5-press, and 3-press groups. All participants completed the full trial protocol as planned, ensuring valid results.

Baseline characteristics showed no significant differences among groups: 7-press group (3 male, 3 female; mean age 23.2$\pm$2.6$years$; $height$170.2$\pm$5.7cm; $weight$54.5$\pm$5.8kg); 5$-$ $pressgroup$(4$male$, 2$female$; age21.3$\pm$0.8$years$; $height$169.3$\pm$8.6cm; $weight$64.0$\pm$10.4kg); 3$-$ $pressgroup$(2$male$, 4$female$; age24.7$\pm$4.8$years$; $height$165.5$\pm$6.7cm; $weight$59.0$\pm$20.4kg)($\chi^{2}=1.33, F=1.66, F=0.74, F=0.73, P>0.05), confirming comparability.

Imaging and Temperature Findings

No participants exhibited radiographic features of scoliosis (Cobb angle >20°), osteoporosis, or vertebral fracture. Post-intervention, no significant differences were found among groups in mean lesion area temperature, T3 left (T3 L) temperature, T4 left (T4 L) temperature, or T4 right (T4 R) temperature

(P>0.05). However, the 3-press group showed significantly decreased temperatures at T3 R and T4 R post-intervention (P<0.05). Differences in temperature changes among groups were not statistically significant for mean lesion area [0(-0.42,0.25)], T3 L [0.11(-0.25,0.20)], T3 R [-0.18(-0.42,0.02)], T4 L [0.04(-0.23,0.12)], or T4 R [-0.09(-0.22,0.07)] (H=2.54, 1.31, 1.81, 0.95, 5.72, P>0.05). See and [Figure 2: see original paper].

Muscle Tone Changes

Post-intervention, significant differences among groups were observed in muscle tension at T3 L at 0.2 kg, T3 R at 0.2 kg, T4 L at 0.2 kg, 0.5 kg, and 0.8 kg, and T4 R at 0.2 kg and 0.5 kg (P<0.05). Within the 7-press group, T3 L muscle tension at 0.2 kg and 0.5 kg showed significant improvement post-intervention (P<0.05). See .

Pain Threshold Changes

Post-intervention, no significant differences were found among groups in pressure pain thresholds at T3 L, T3 R, T4 L, or T4 R (P>0.05). However, the 3-press group exhibited significantly decreased thresholds at all four sites post-intervention (P<0.05), while the 7-press group showed decreases at T3 L and T3 R only (P<0.05). Differences in threshold changes among groups were not significant for T3 L [-18.25(-24.28,-7.30)], T3 R [-13.35(-24.40,-2.33)], T4 L [-14.15(-19.35,-4.50)], or T4 R [-13.70(-18.30,-0.48)] (H=3.87, 3.83, 2.75, 3.19, P>0.05). See .

Safety Evaluation

All 18 patients completed the trial without dropout. No adverse events occurred during treatment, and no serious adverse reactions were reported, confirming the safety of the manipulation.

Discussion

Significance of Measuring Dose-Heat Effect Relationship

The *Suwen · Tiaojing Lun* states: "When cold-dampness attacks, skin becomes flaccid, muscles tighten, nutritive qi stagnates, and defensive qi departs, causing deficiency. Pressing replenishes qi, warming the area, thus producing comfort without pain." This indicates that pressing techniques can replenish qi to warm nutritive blood, resulting in abundant defensive qi, smooth blood flow, elevated body temperature, and pain relief—"when warm qi arrives, pain ceases." Manual therapy accelerates blood circulation, enhances metabolism, significantly reduces pro-inflammatory cytokines TNF-α and IL-1β expression to achieve analgesia [41], and improves soft tissue tension by releasing adhesions and relieving neurovascular compression. Therefore, the "warm qi arrival" from pressing

techniques improves blood flow, reduces pain, and enhances soft tissue tension, embodying the principle "warm qi arrives, pain stops."

In joint mobilization, Grade IV mobilization involves small-amplitude movements at the end range of joint motion, producing anti-hyperalgesia through descending inhibition of serotonin and norepinephrine, and nitric oxide synthase immunohistochemical expression [22-23]. Studies show correlations between manual force magnitude/direction and therapeutic efficacy [24]. In Lin's slow thrusting technique, practitioners emphasize maintaining contact with or without compression on target joints, applying small-amplitude, slow thrusts (pressing) at the end range of passive or active joint movement, contacting the end range each time while sensing soft tissue elasticity and resistance—equivalent to Grade IV mobilization intensity. This is particularly suitable for young patients with low pain tolerance, petite female patients, or robust patients requiring rapid thrusting followed by slow thrusting.

Research indicates that manual signal energy varies with biomechanical factors such as duration and frequency [18-19]. While modern medicine has achieved some understanding of manual analgesic mechanisms and thermal effects—for example, Tuina reduces peripheral nociceptive C-fiber activity [20] and thumb pressure combined with temperature influences thermal effects [21]—the biomechanical-thermal effect-efficacy correlation in spinal manipulation remains underexplored. Lin's technique uses 3-7 presses as the standard range, offering a simple, rapid method to restore spinal biomechanical balance, yet the relationship between press count and thermal effect-efficacy warrants investigation.

Biothermophysical Evaluation of Different Frequencies

Different manual frequencies can resonate with inherent frequencies of body parts, generating bioresonance that enhances penetration and therapeutic effect. Du Yiwen et al. [26] demonstrated that abdominal massage at 50-100 times/min showed no significant effect on erythrocyte rosette rate in spleen-deficiency rabbits, while 101-150 and 151-200 times/min were effective frequency ranges. Fang Dansi et al. [27] found that low-frequency clearing Tianhe River technique showed no significant temperature reduction in children with exogenous fever, whereas medium and high frequencies effectively reduced body temperature. Our study's lack of significant temperature improvement may be because the low-velocity, low-amplitude technique used differs from prolonged manipulations like kneading or rubbing, and the short contact time may be insufficient for thermal imaging detection [28]. Additionally, individual differences in infrared thermal response warrant further stratified research by constitution.

For muscle tone measurement, our instrument has been extensively clinically validated [30]. Increased muscle tone correlates closely with pain, as seen in needle-knife therapy principles that reduce soft tissue tension [28,31]. Post-intervention differences among groups may relate to the technique's primary

action on spinous processes rather than lateral soft tissues, and because human soft tissue is viscoelastic with stress-strain hysteresis, stress relaxation, and creep characteristics, measured values represent comprehensive tension across tissue layers. Future studies require more precise instruments to determine whether Lin's technique's analgesic mechanism acts through altering bilateral muscle tension.

Pain threshold measurement is influenced by mechanical stimulation and thoracic anatomy. Our team previously used muscle tone and pain thresholds to assess manual therapy for lumbar disease, finding decreased post-treatment values [32]. Similarly, this study showed lower post-treatment pain thresholds. Pain is an unpleasant emotional state interpreting nociceptive input influenced by memory, emotion, pathology, genetics, and cognition [33]. Nociceptive stimuli activate C-fiber nociceptors, inducing central plasticity in the nociceptive system that can respond to previously non-nociceptive low-threshold input, generating pain [34]. Thoracic facet joints are highly innervated, with nerve endings distributed in subchondral bone, synovium, synovial folds, and capsules, actively transmitting pain [3,35]. Joint capsules and surrounding structures are filled with nociceptors that fire when stretched or compressed, and mechanical stimulation of facet joints has been proven to cause back pain [36]. Our pain threshold method used a slightly sharp probe pressed at designated sites—this noxious stimulation, combined with numerous nociceptors around thoracic facets, may have sensitized volunteers during repeated measurements, lowering thresholds. The subjective nature of pain tolerance and lack of standardized reference points represent limitations.

This pilot study provides reference for combining infrared thermal imaging with Tuina but has limitations: (1) small sample size requiring expansion; (2) individual variability in thermal response necessitating constitution-stratified studies. Future research should employ more sophisticated equipment with larger samples and multiple levels to investigate the biomechanical-thermal effect-efficacy correlation in Lin's technique, advancing its foundational research.

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