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Original Article

Comparison of two acupuncture stimulation techniques at Hegu (LI4) on muscle and fascia stiffness, blood flow, and quality of life in healthy female volunteers

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Abstract: Objective: To evaluate the effects of Hegu (LI4) induced by two acupuncture stimulation techniques in healthy females using Shear Wave Elastography (SWE). Methods: Forty-five right-handed healthy females were recruited in this study. Participants first received "Lifting-Thrusting" acupuncture stimulation (LT AS) at the right LI4 acupoint, followed by "Shaoshanhuo" acupuncture stimulation (SSH AS) at the left LI4 two weeks later. De-qi responses were measured using a professional data collection platform (Wenjuanxing). Muscle and fascia stiffness at the Hegu acupoint were assessed using SWE, and blood flow of the first dorsal metacarpal arteries (FDMA) was measured using Color Doppler Flow Imaging (CDFI) at three time points: before intervention (T0), 1 minute after intervention (T1), and 5 minutes after intervention (T2). Quality of life was evaluated using the 36-Item Short Form Health Survey (SF-36). Results: Compared with the LT AS, SSH AS induced stronger acupuncture sensation and greater expansiveness. SWE measurements demonstrated significant differences between the two acupuncture techniques in muscle and fascia stiffness, although these differences were not time-dependent. CDFI showed a transient increase in peak systolic velocity (PSV) and resistance index (RI) of the FDMA, which then recovered; end-diastolic velocity (EDV) and S/D ratio did not show significant changes. Infrared thermal imaging showed a decrease in the initial temperature, followed by acupuncture-induced elevation, with significant differences over time and between groups. Both acupuncture stimulation methods contributed to comparable SF-36 scores. Conclusion: Although the two acupuncture stimulation methods (LT AS and SSH AS) differ in terms of acupuncture sensation and de-qi spread, they show similar temporal patterns regarding their effects on muscle/fascia stiffness, FDMA hemodynamics, and quality of life. However, the integrated effects differ significantly between the two techniques.

Keywords: Hegu (LI4), acupuncture stimulation, de-qi, SWE, CDFI

Introduction

Acupuncture is frequently employed to alleviate various symptoms. Clinical evidence indicates that the efficacy of acupuncture can be enhanced through specific acupuncture stimulation (AS), and different AS techniques can elicit distinct effects even on the same acupoint [1, 2]. For instance, acupuncture involving deeper insertion into the segmental muscles has been shown to be more effective than shallow insertion for patients with chronic low back pain [3]. Nevertheless, it remains uncertain whether different manipulations produce distinct effects on muscle and fascia. In particular, there is a lack of direct comparative studies that employ objective biomechanical indicators (e.g., tissue stiffness, local blood flow) to evaluate different acupuncture techniques. It has been demonstrated that acupuncture can not only increase skin microcirculation but also influence systemic circulation [4] and organ-specific perfusion [5-9]. The first dorsal metacarpal artery (FDMA), originating from the radial artery beneath the Hegu (LI4) point, has not been thoroughly investigated regarding blood perfusion changes following AS.

Shear Wave Elastography (SWE) utilizes shear waves generated by Acoustic Radiation Force

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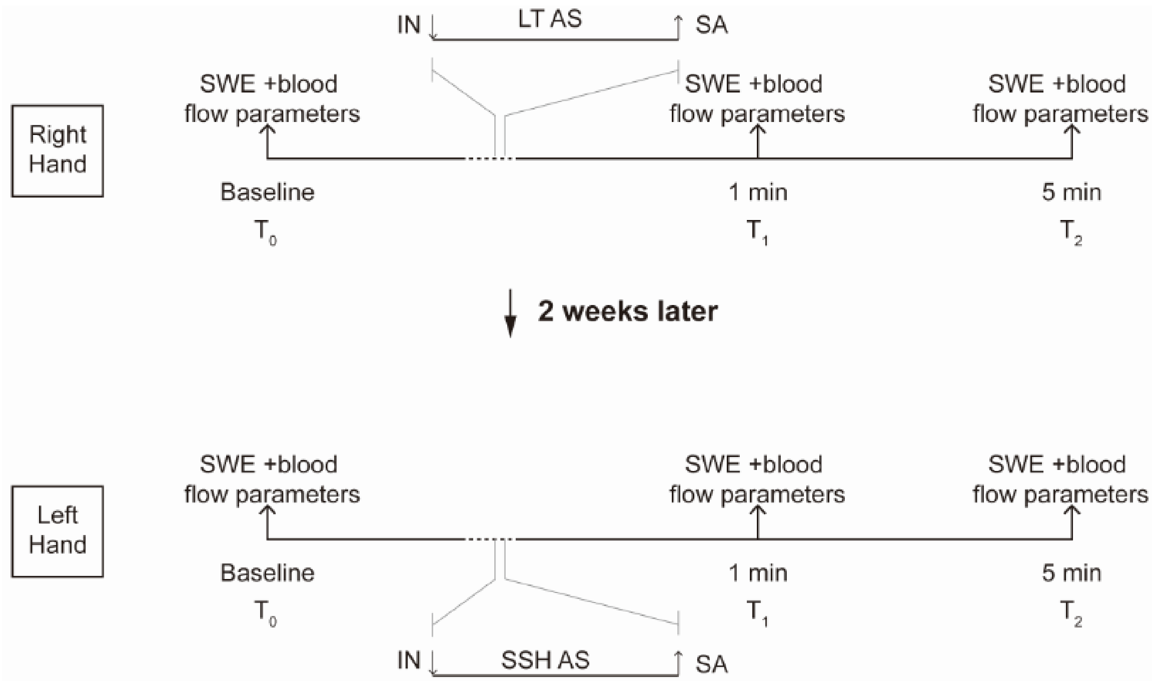

Figure 1. Study design. Notes: SWE, Shear Wave Elastography; LT AS, "Lifting-Thrusting" acupuncture stimulation; SSH AS, "Shaoshanhuo" acupuncture stimulation; T0, pre-intervention; T1, 1-minute post-intervention; T2, 5 minutes post-intervention.

Impulse (ARFI) to assess tissue stiffness. Quantitative elasticity values are derived from the velocity of shear waves traversing the tissues, and previous studies have demonstrated a linear relationship between the SWE measurements and muscle stiffness [10, 11]. In general, higher passive muscle stiffness corresponds to larger SWE values, and SWE has shown comparable performance in evaluating fascias. SWE is inexpensive, non-invasive, fast, and well-accepted by patients [12].

The principal objective of this study was to evaluate the effects of two distinct acupuncture stimulation methods on LI4 by examining SWE values of muscle and fascia, as well as blood flow in the FDMA. Additionally, de-qi responses of LI4 were assessed. This study is innovative in its pioneering combined employment of SWE and color Doppler flow imaging (CDFI) to objectively and quantitatively compare the immediate biomechanical effects of different acupuncture techniques on local tissue stiffness and arterial blood flow. The findings provide visual and objective evidence supporting traditional clinical observations regarding the differential therapeutic effects of acupuncture techniques, thereby facilitating the standardization and optimization of acupuncture operations. Additionally, the non-invasive evaluation paradigm established in this study can be applied to future studies investigating acupuncture effects at other acupoints or in pathological conditions.

Material and methods

A total of 45 right-handed, healthy females were recruited for this study. Individuals with mental or medical disorders, right-hand injuries, tobacco, tea, or coffee consumption, pregnancy, and use of any medications within four weeks prior to the trial were excluded. All participants provided written informed consent. This study was approved by the Ethics Committee of The Second Hospital of Shandong University.

All participants received "Lifting-Thrusting" acupuncture stimulation (LT AS) at the right LI4 acupoint, followed by "Shaoshanhuo" acupuncture stimulation (SSH AS) at the left LI4 two weeks later (**Figure 1**).

Acupuncture stimulation methods

Two acupuncture stimulations, namely LT AS and SSH AS, were applied according to Lu

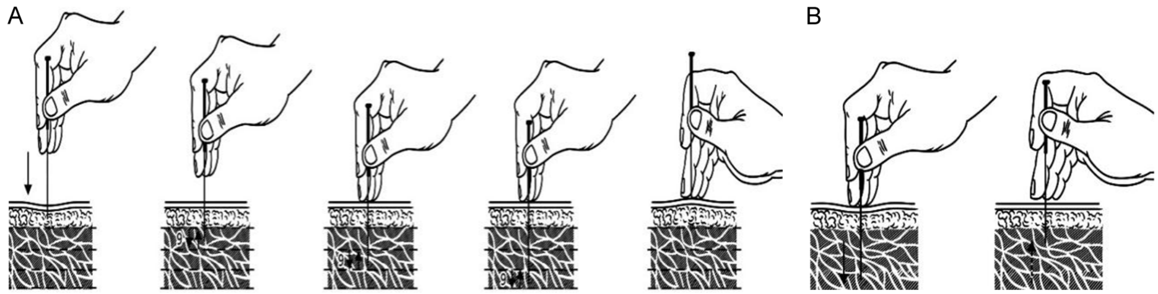

Figure 2. Schematics of the two acupuncture stimulation approaches. A: Shaoshanhuo acupuncture stimulation (SSH AS); B: Lifting-Thrusting acupuncture stimulation (LT AS).

Shoukang's "Needling and Moxibustion Methods". Sterile, disposable stainless-steel needles (Huatuo, 0.30 mm×40 mm) were used. A two-week interval between the two AS sessions was implemented to minimize potential residual effects of prior acupuncture. All procedures were performed under the supervision of a licensed and experienced acupuncturist (**Figure 2**).

SSH AS

The depth of acupoint was divided into shallow, middle, and deep layers. Participants breathed naturally during the procedure. The acupuncturist inserted the needle into the shallow layer to achieve "de-qi", described as an exhalation-like clearance sensation. Heavy insertion combined with light lifting was repeated 9 times continuously. Subsequently, the needle was inserted into the middle and deep layers, following the same lifting-thrusting pattern, repeated 9 times. If participants reported a burning sensation under the needle, the needle was withdrawn to the shallow layer. If there was no heat sensation, stimulation was repeated twice before the needle was rapidly withdrawn.

LT AS

The needle was initially inserted vertically to a depth of 2 cm, followed by lifting-thrusting manipulation to induce de-qi or other needling sensations. In this technique, the needle was pressed downward and then lifted approximately 1 cm, emphasizing deep insertion with gentle lifting.

SWE examination

Before SWE examination, a custom-made bracket was placed on the examination bed to support the sonographer's operating hand, thereby minimizing the pressure exerted by the probe on the skin. Participants were seated on a chair facing the examiner, with the upper limbs positioned comfortably: the elbow was flexed at about 150°, the forearm was slightly pronated, and the hand was maintained in a relaxed resting position. Stiffness was measured 5 times (**Figure 3**).

All ultrasound measurements were performed by an experienced sonographer using a Mindray Nuewa R9S ultrasound system (Shenzhen Mindray Bio-medical Electronics Co., Ltd, Guangdong, China) equipped with an L11-3U linear-array transducer. Measurements were obtained before acupuncture (T0), 1 min after acupuncture (T1), and 5 min after acupuncture (T2). All subjects underwent standard conventional B-mode ultrasound examinations to exclude structural abnormalities of the hand, including muscle tears, hematomas, or tumors.

To ensure consistency of the measurement site, the ultrasound probe was specifically positioned over a predefined region of interest (ROI) corresponding to the LI4 acupoint. B-mode gray-scale images were captured to verify the anatomical location and to avoid bone structures or prominent blood vessels within the ROI. During SWE, the long axis of the transducer was aligned parallel to the muscle fibers. SWE measurements of muscle and fascia stiffness were obtained at 15-20 mm beneath the skin surface at Hegu acupoint. After activation of the SWE mode and adequate filling the ROI color area (indicating tissue elasticity), the built-in Quantitative Analysis System (Q-BOX) automatically calculated the maximum, minimum, and mean SWE values within a circular sampling area (diameter: 5 mm) located in the

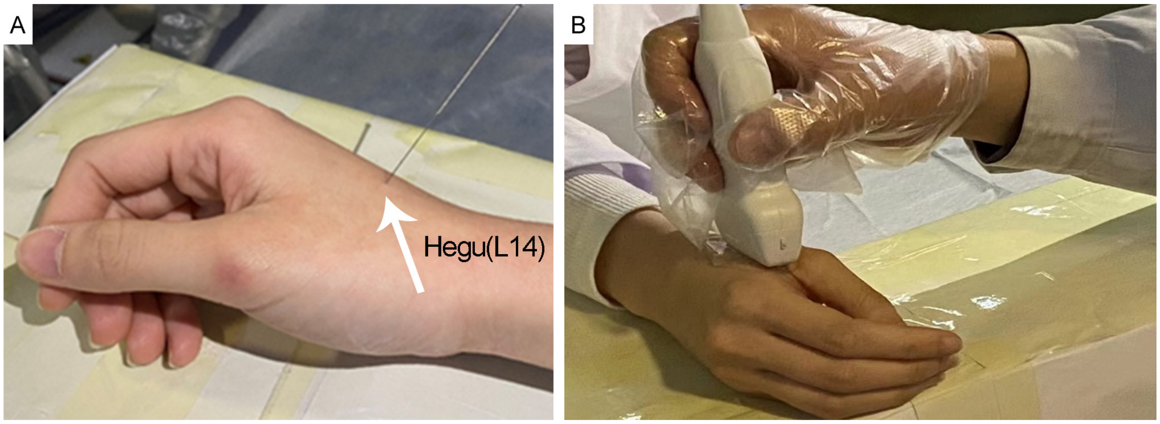

Figure 3. Acupoint selection for Hegu and subject positioning. A: A self-made bracket was set on the examination bed to support the measuring hand of the sonographer and thus minimize the pressure exerted by the probe on the skin. B: The participant sat in a chair facing the examiner, with the upper limbs extended in a comfortable state.

ROI center. Five consecutive measurements were conducted for each tissue, and the average value was recorded for subsequent analysis.

CDFI of the first dorsal metacarpal arteries

Participants maintained the same posture as during the SWE examination. The FDMA was first identified using CDFI and the segment with the most obvious blood flow signal was selected to capture a clear pulse Doppler spectrum. Three to five continuous, morphologically clear spectra were used to measure peak systolic blood velocity (PSV), end-diastolic blood velocity (EDV), the S/D ratio (PSV/EDV), and resistance index (RI). The angle between the blood flow direction and the ultrasound beam was maintained between 45° and 60°.

De-qi response measurement

Acupuncture sensations were assessed using the Massachusetts General Hospital (MGH) Acupuncture Sensation Scale (MASS), encompassing soreness, dull pain, pressure, heaviness, fullness, numbness, sharp pain, warmth, coolness, throbbing, or other perceptions. Each sensation was quantified on a scale of 0-10, where 0 indicated no sensation, 1-3 mild, 4-6 moderate, 7-9 severe, and 10 unbearable. A cumulative MASS score of 3 or above, excluding sharp pain, was considered indicative of a de-qi response.

The Acupuncture Sensation Spreading Scale was used as a supplementary measure to assess the localization and spread of de-qi sensations throughout the limb. Markers on this scale included "none", "localized", "digit/wrist", "lower forearm", "upper forearm", and "beyond". After AS, participants reported their sensations on a professional platform (Wenjuanxing).

Temperature measurement

Infrared thermal images were analyzed using the NS9300 Image Processor Pro II program. Temperature values were collected from a circular area of 1 cm diameter centered at the Hegu (LI4) acupoint and used for statistical analysis.

Quality of life assessment

The quality of life of all participants was evaluated using the 36-Item Short Form Health Survey (SF-36), covering dimensions of physical functioning, bodily pain, general health, and vitality. Each dimension was scored from 0 to 100 points, with higher scores indicating better quality of life.

Statistical analysis

Continuous variables were presented as mean ± standard deviation (x ± s), and between-group comparisons were performed using paired-sample t-test. Categorical data were expressed as count and percentage (n, %) and compared between groups busing chi-square test or Fisher's exact test, as appropriate. A two-way repeated measures analysis of variance (ANOVA) was employed, with stimulation mode (LT AS vs. SSH AS) and measurement timing

Table 1. Demographic and clinical data of the participants

Groups	N	Gender (female)	Age	Right-handed	BMI (kg/m²)
LT AS group	44	44	21.00 (20.00, 23.00)	44	22.23±1.93
SSH AS group	45	45	21.00 (20.50, 23.00)	45	22.25±1.92
Z/t	-	-	-0.289	-	0.049
P	-	-	0.772	-	0.961

Note: LT AS, Lifting-Thrusting acupuncture stimulation; SSH AS, Shaoshanhuo acupuncture stimulation; BMI, body mass index.

Table 2. Intensity of acupuncture sensation in people induced by two acupuncture stimulations

Item	LT AS group (n=44)	SSH AS group (n=45)	Z	P
Soreness	2.00 (1.00, 3.75)	3.00 (1.00, 5.00)	-1.695	0.090
Dull pain	1.00 (0.00, 2.00)	3.00 (1.00, 4.50)	-3.536	<0.001
Pressure	1.00 (0.00, 2.00)	3.00 (0.50, 5.00)	-3.402	0.001
Heaviness	1.00 (0.00, 2.00)	1.00 (0.00, 4.00)	-1.241	0.215
Fullness	1.00 (1.00, 2.00)	2.00 (1.00, 3.50)	-1.715	0.086
Numbness	2.00 (1.00, 2.00)	2.00 (1.00, 4.00)	-1.326	0.185
Sharp pain	1.00 (0.00, 1.75)	3.00 (1.00, 5.00)	-4.352	<0.001
Coolness	0.00 (0.00, 1.00)	0.00 (0.00, 1.00)	-0.365	0.715
Warmth	0.00 (0.00, 1.00)	0.00 (0.00, 1.00)	-0.578	0.563
Throbbing	0.00 (0.00, 1.00)	3.00 (1.00, 4.00)	-4.806	<0.001

Note: LT AS, Lifting-Thrusting acupuncture stimulation; SSH AS, Shaoshanhuo acupuncture stimulation.

(T0, T1, T2) as within-subject factors, to evaluate the effects on SWE values and blood flow parameters. When a significant interaction effect was observed, simple-effects analyses were conducted, and the significance level was adjusted using the Bonferroni correction. If the interaction was not significant, the main effects of stimulation mode and time were examined. For significant main effects involving factors with more than two levels, post-hoc pairwise comparisons were performed, with the significance level corrected by the Bonferroni method. All statistical analysis was processed using R software (4.0.5), and all figures were generated using GraphPad Prism 8. A two-sided *P* value <0.05 was deemed statistically significant.

Results

A total of 45 participants were included in this study. One participant failed to complete the LT AS procedure. Detailed baseline characteristics are presented in **Table 1**.

De-qi responses assessed by the MASS

As shown in **Table 2**, sensations of soreness and numbness were predominant in the LT AS group, while soreness, dull pain, pressure, sharp pain, and throbbing were the most prominent sensations reported in the SSH AS group. The SSH AS group reported higher intensity scores for the dull pain, pressure, sharp pain, and throbbing than the LT AS group (P<0.05). Overall, SSH AS produced more intense acupuncture sensation than LT AS.

De-qi responses assessed by acupuncture sensation spreading scale

In terms of the spatial spread of de-qi sensations, "none" was the most frequently reported category in the LT AS group, followed by "localized". Conversely, "localized" was predominant in the SSH AS group, followed by "none" and "digit/wrist". The extent of de-qi sensation spreading induced by SSH AS was more pronounced than that induced by LT AS (P<0.05; **Figure 4**).

SWE

The SWE values of the muscle and fascia beneath the Hegu acupoint in the two groups are detailed in **Table 3**. For muscle SWE values, two-way repeated measures ANOVA revealed a significant interaction between stimulation mode and time (P=0.046). In addition, a significant main effect of stimulation mode (P<0.001) was observed; however, the main effect of time was not significant (P>0.05). In terms of fascia SWE values, a significant main effect of stimulation mode was noted (P<0.001). However, neither the main effect of time nor the interaction effect between stimulation mode and time reached statistical significance (P>0.05; **Figures 5A-F**, **6A-F**).

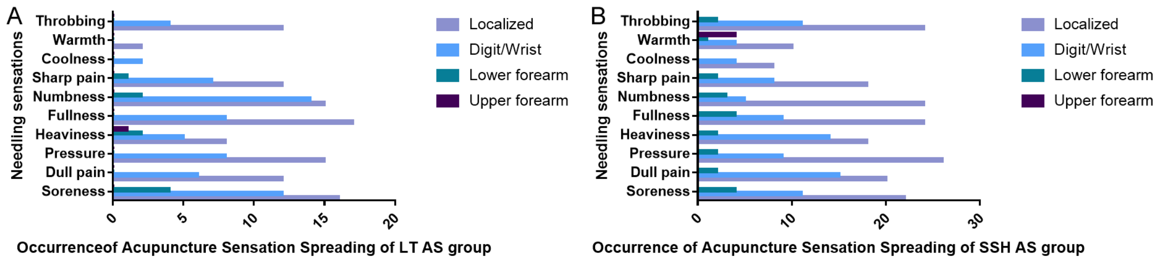

Figure 4. Distribution of de-qi sensation spreading following LT AS (A) and SSH AS (B). Notes: LT AS, Lifting-Thrusting acupuncture stimulation; SSH AS, Shaoshanhuo acupuncture stimulation.

Table 3. Shear wave velocity of muscle and fascia under the Hegu acupoint

Groups	N	T	SWE of Muscle (kPa)	SWE of Fascia (kPa)
LT AS group	44	T0	4.79±1.11	7.27 (5.54, 8.72)
		T1	4.15±1.34	6.45 (5.15, 7.92)
		T2	4.22±1.44	6.10 (5.58, 7.37)
SSH AS group	45	T0	4.34±0.93	6.80 (5.22, 8.42)
		T1	4.39±1.44	6.51 (4.96, 8.86)
		T2	4.07±0.83	7.32 (5.36, 9.03)
Group main effect p			<0.001	<0.001
Time main effect p			>0.05	>0.05
Interaction effect p			0.046	>0.05

Note: LT AS, Lifting-Thrusting acupuncture stimulation; SSH AS, Shaoshanhuo acupuncture stimulation; SWE, Shear wave elastography; T0, pre-intervention; T1, 1 minute post-intervention; T2, 5 minutes post-intervention.

CDFI of the FDMA

The CDFI values of the FDMA in the LT AS and SSH AS groups are presented in **Table 4**. For PSV, no significant interaction effect was observed between stimulation mode and time (P>0.05). However, significant main effects of both time and stimulation mode were detected (both P<0.001). Post-hoc analyses showed that PSV increased significantly at T1 compared with T0 (P=0.001) and subsequently decreased significantly at T2 compared with T1 (P<0.001), returning to a level comparable to baseline (P>0.05 vs. T0). For EDV, neither the interaction effect nor the main effect of time was significant (both P>0.05). In contrast, a significant main effect of stimulation mode was identified (P<0.001). Regarding the RI, a significant main effect of time was observed (P=0.013), whereas the interaction effect was not significant (P>0.05). The main effect of stimulation mode was significant (P<0.001). Post-hoc analyses revealed that RI increased significantly at T1 compared with T0 (P=0.007), while no significant difference was observed between T1 and T2 or between T2 and T0 (both P>0.05).

For the S/D ratio, neither the interaction effect nor the main effect of time reached statistical significance (both P>0.05). However, a significant main effect of stimulation mode was observed (P<0.001) (**Figures 5G-I**, **6G-I**).

Temperature measurement

As shown in **Table 5**, significant time, interaction, and stimulation mode effects were observed for infrared temperature (P<0.001). Post-hoc analyses showed that infrared temperature changed significantly across time points (P<0.001).

Quality of life

Quality-of-life outcomes evaluated using the SF-36 scale are summarized in **Table 6**. No significant inter-group differences were identified in the domains of physical functioning, bodily pain, general health, or vitality (all P>0.05).

Discussion

The study aimed to assess the effects of LI4 stimulation using two acupuncture stimulations in healthy females via SWE. The main findings were as follows: (1) Compared with LT AS, SSH AS elicited more pronounced acupuncture sensations and greater spatial spread. (2) Both acupuncture stimulations demonstrated minimal effects on muscle and fascia stiffness beneath the Hegu acupoint as measured by SWE. (3) Acupuncture initially enhanced the

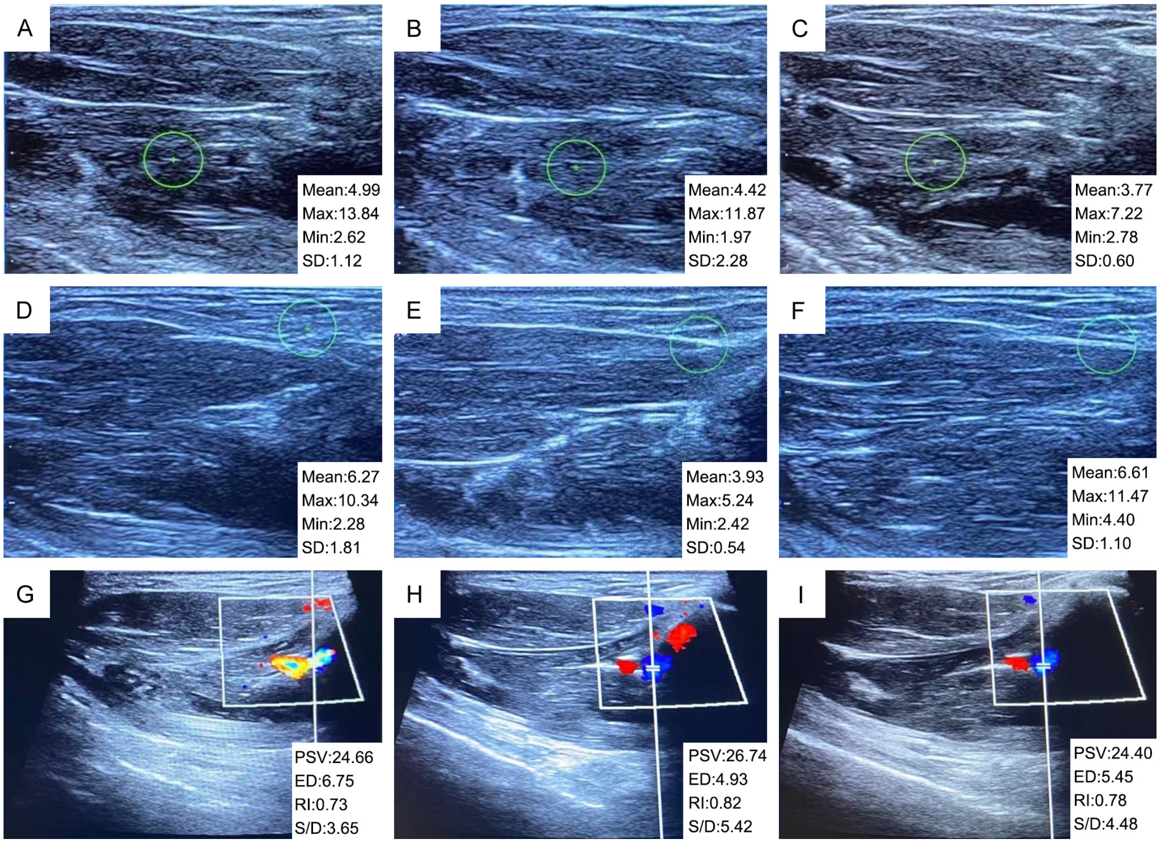

Figure 5. Ultrasound images of muscle and fascia stiffness and first dorsal metacarpal artery (FDMA) blood flow in a 21-year-old female before and after SSH AS of the left hand. A-C: SWE of the muscle at T0-T2; D-F: SWE of the fascia at T0-T2; G-I: CDFI of the FDMA at T0-T2. Notes: SSH AS, Shaoshanhuo acupuncture stimulation; SWE, Shear wave elastography; CDFI, Color Doppler Flow Imaging; T0, pre-intervention; T1, 1-minute post-intervention; T2, 5 minutes post-intervention.

blood flow in the FDMA, which subsequently decreased.

SSH AS induced a more intense acupuncture sensation and a broader sense of stretching. Acupuncture stimulation, fundamentally a mechanical stimulation, likely evokes de-qi sensations by activating sensory receptors in the skin, subcutaneous tissue, fascia, tendons, and muscles, regardless of whether tissue contraction occurs [14]. The activation of different sensory receptors in various tissue layers beneath the acupuncture points may explain individual sensation of de-qi. As mentioned earlier, SSH AS penetrates deeper than LT AS. In our de-qi response assessment, soreness, fullness, and numbness sensations were the most pronounced sensations during LT AS, whereas fullness, numbness, and throbbing were dominant during SSH AS. Moreover, while de-qi spread was limited in most LT AS cases, most cases in SSH AS group reported clear spreading, mainly classified as "localized". These findings indicate that needling depth is associated with both the intensity and spatial distribution of de-qi sensations. This observation is consistent with previous experimental research. In an experimental study comparing superficial and deep needling techniques at Sanyinjiao (SP6), Yinlingquan (SP9), Zusanli (ST36), and Xuanzhong (GB39), deep needling significantly enhanced both de-qi sensations and pain thresholds [15]. Therefore, needling depth is crucial in eliciting de-qi sensations and may influence treatment effects.

Through SWE-based evaluation, acupuncture stimulation was found to differentially affect muscle and fascia stiffness at Hegu acupoint. Muscle stiffness varied significantly depending on intervention types and the interaction between intervention and time, whereas fascia

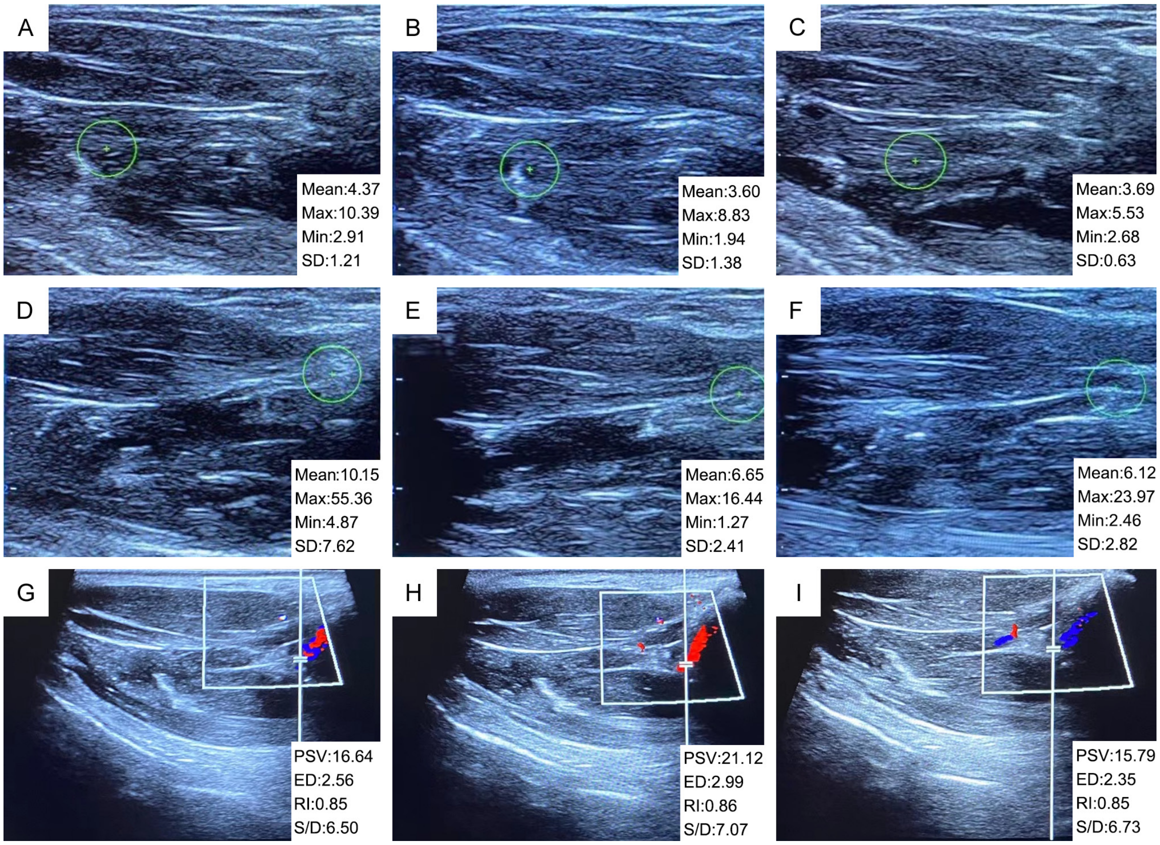

Figure 6. Ultrasound assessment of muscle and fascia stiffness and first dorsal metacarpal artery (FDMA) blood flow in a 21-year-old female before and after LT AS of the right hand. A-C: SWE of the muscle at T0-T2; D-F: SWE of the fascia at T0-T2; G-I: CDFI of the FDMA at T0-T2. Notes: LT AS, Lifting-Thrusting acupuncture stimulation; SWE, Shear wave elastography; CDFI, Color Doppler Flow Imaging; T0, pre-intervention; T1, 1-minute post-intervention; T2, 5 minutes post-intervention.

Table 4. CDFI of the first dorsal metacarpal arteries

Groups	N	T	PSV	EDV	RI	S/D
LT AS group	44	T0	17.81±3.19	4.31±1.88	0.75±0.08	4.60 (3.52, 5.72)
		T1	20.25±4.56*	4.69±2.66	0.79±0.07	4.41 (3.59, 6.30)
		T2	18.09±4.12#	4.47±1.98	0.77±0.10	4.23 (3.27, 5.97)
SSH AS group	45	T0	17.55±3.86	4.89±1.96	0.75±0.06	4.61 (3.40, 5.23)
		T1	20.65±4.88*	4.36±1.75	0.79±0.07	4.25 (3.13, 5.68)
		T2	18.49±5.11#	4.00±2.36	0.77±0.09	4.66 (3.66, 6.31)
Group main effect p			<0.001	<0.001	<0.001	<0.001
Time main effect p			<0.001	>0.05	0.013	>0.05
Interaction effect p			>0.05	>0.05	>0.05	>0.05

Note: LT AS, Lifting-Thrusting acupuncture stimulation; SSH AS, Shaoshanhuo acupuncture; PSV, the peak systolic blood flow velocity; ED, end-diastolic blood flow velocity; RI, blood flow resistance index; S/D, PSV/ED; CDFI, Color Doppler Flow Imaging; T0, pre-intervention; T1, 1-minute post-intervention; T2, 5 minutes post-intervention. *P<0.05 vs. T0 at the same group; #P<0.05 vs. T1 in the same group.

stiffness was significantly affected only by the intervention scheme. Examining post-AS muscle/fascial stiffness alterations is clinically meaningful, as a characteristic "grasping" sensation is perceived when the needle pierces the muscles and fascia beneath the acupoint.

Table 5. The changes in infrared thermal imaging temperature of the Hegu acupoint area

Groups	N	T	Infrared thermal imaging temperature
LT AS group	44	T0	36.24±0.36
		T1	35.25±0.39
		T2	36.89±0.22
SSH AS group	45	T0	36.48±0.34
		T1	35.81±0.18
		T2	36.93±0.31
Group main effect p			<0.001
Time main effect p			<0.001
Interaction effect p			<0.001

Note: LT AS, Lifting-Thrusting acupuncture stimulation; SSH AS, Shaoshanhuo acupuncture; PSV, the peak systolic blood flow velocity; T0, pre-intervention; T1, 1-minute post-intervention; T2, 5 minutes post-intervention.

Table 6. Inter-group comparison of quality of life

Quality of life	LT AS group (n=44)	SSH AS group (n=45)	t	P
Physical functioning (points)	89.70±5.32	90.51±3.80	0.828	0.410
Bodily pain (points)	81.00±9.15	81.87±6.86	0.508	0.613
General health (points)	74.86±11.74	74.96±12.75	0.038	0.969
Vitality (points)	71.25±11.83	74.38±12.79	1.198	0.234

Note: LT AS, Lifting-Thrusting acupuncture stimulation; SSH AS, Shaoshanhuo acupuncture stimulation.

This observation supports the notion that acupuncture efficacy is primarily mediated by its effects on muscles and/or fascia [16]. The underlying mechanisms of acupuncture have been increasingly explored. The fascia acupuncture hypothesis theory, positing the role of fascial planes as channels, has attracted our attention [17]. The theory holds that stimulating the fascia can trigger tissue activity, thus impacting physiological functions. This study used SWE to assess AS's impact on fascia/muscle stiffness at Hegu. The results showed that although significant differences were confirmed between the two schemes in stiffness, the change was not time-dependent. This may be related to the differences in needle retention time, stimulation depth, or cumulative stimulation dose between LT AS and SSH AS. The similarity in temporal patterns (a brief change followed by recovery) suggests that the influence of acupuncture on local tissues properties are transient. Although there is a lack of similar studies for direct comparison, recent evidence reported that all upper-extremity muscles showed mean SWE value decreases and thickness increases post-saline injections; however, only each connection exists between these alterations and SWE value changes [18]. Differences in needle insertion sites (Hegu versus abdominal muscle) and the use of saline injections may explain the discrepancy between their findings and ours, as saline administration itself could transiently decrease muscle elasticity. Additionally, an initial enhancement of blood perfusion in the FDMA was observed, followed by a noticeable drop, consistent with the transient biomechanical effects noted in muscle and fascia.

The FDMA originates from the radial artery and courses beneath the Hegu (LI4) acupoint. In this study, we observed AS-induced noticeable perfusion alterations within these arteries. Hsin Hsiu et al. analyzed post-AS skin blood-flow signal frequencies at Hegu and two adjacent non-acupoints using laser Doppler flowmetry (LDF). Their findings demonstrated a significant increase in blood flow at Hegu, characterized by a marked reduction in the relative energy contribution within the 0.02-0.06 Hz frequency band and a notable rise within 0.4-1.6 Hz frequencies, whereas no marked changes were observed at the non-acupoints [19]. Previous studies reported an evident elevation in the mean blood-flux ratio at the contralateral Hegu acupoint following acupuncture stimulation [4, 20]. Furthermore, acupuncture not only enhances local microcirculation [6-9] but also impacts systemic circulation and organ-specific blood circulation [5]. Herein, acupuncture stimulation notably increased FDMA perfusion, implicating AS in the broader autonomic nervous system. This further confirms the importance of the autonomic nervous system in acupuncture effect modulation [21, 22]. Meanwhile, we observed that some FDMA-associated blood flow parameters (represented by PSV) decreased significantly after a brief increase, possibly due to the shorter AS duration. Finally, quality-of-life improvement was comparable under the two acupuncture stimulation techniques.

Several limitations in this research are present. First, to minimize the influence of potential confounders like gender and age, this study only included 45 healthy young right-handed women. Consequently, the generalizability of the findings to other populations may be limited. Future studies with larger and more diverse populations are warranted to improve the external validity of the results. Second, all participants received LT AS on the right side first, followed by SSH AS on the left side after a two-week interval. This design was adopted to ensure consistency in both the intervention procedures and assessment conditions. Although the two-week washout period and comparable baseline results support the feasibility of this approach, residual confounding factors such as sequence effect, carryover effects, and laterality-related differences, cannot be completely excluded. A random crossover design should be adopted in the future to further enhance the reliability of the conclusions. Third, the relatively short duration of acupuncture stimulation restricted our assessment to its immediate effects. Future investigations employing longer stimulation durations and extended follow-up periods are essential to characterize the local and systemic effects of the two techniques.

Conclusion

Although LT AS and SSH AS elicited different acupuncture sensations and de-qi propagation, they produced similar temporal patterns in muscle and fascia stiffness and FDMA perfusion. Both techniques showed some consistency in short-term local tissue responses and quality-of-life outcomes. These findings provide objective insights into the mechanisms of acupuncture and may help optimize and standardize acupuncture manipulation techniques.

Disclosure of conflict of interest

None.

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