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Meridian study on the response current affected by acupuncture needling direction

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Abstract

Acupuncture manipulation with needling direction is important for the therapeutic effect based on traditional Chinese medicine theory. However, there is controversy over directional manipulation and therapeutic effect, despite some research showing that acupuncture manipulations may have something to do with therapeutic effect. Moreover, research usually focuses on the therapeutic effects on the acupoints and acupuncture time rather than exploring the manipulation method. This study applies a semiconductor analyzer to investigate the effects of acupuncture manipulation. 10 healthy participants were recruited for the study. We used a cross-over design to compare the effect of different manipulation on individuals. This study employed an Agilent B1500A semiconductor analyzer to investigate the electric characteristics of meridians under directional *supplementation* and *draining* manipulation. We measured the electric current of meridians under different manipulation, and compared the difference between *supplementation* and *draining* manipulation in healthy individuals. The electric current was significantly larger in *supplementation* manipulation compared to *draining* manipulation in the meridians ($P < .001$). The measured electric current in the same manipulation methods did not show a statistical difference between meridians ($P = .094$). The different directional manipulation result in different electric currents in humans. Our finding implies that the *supplementation* and *draining* manipulation may result in different therapeutic effects clinically as the description of traditional Chinese medicine theory. Therefore, directional manipulation may need to be taken into consideration in future acupuncture studies and clinical management.

Abbreviations: ANOVA = analysis of variance, BL = bladder meridian, HT = heart meridian, KI = kidney meridian, SI = small intestine meridian, TCM = traditional Chinese medicine.

Keywords: acupuncture, Chinese medicine, directional manipulation, draining, electricity, meridian theory, supplementation

1. Introduction

Acupuncture is a procedure that uses a specific needle inserted into an acupoint on the surface of the skin, which can be used to treat several kinds of diseases.[1] The meridian theory has developed based on empirical experience accrued over many decades and is the guide to performing acupuncture clinically.[2] *Lingshu*, one of the ancient theories of traditional Chinese medicine (TCM), refers to the acupuncture method as follows: "It is thought that the disease can be divided into *deficiency* or *excess* according to their syndrome type. When the human belongs to *deficiency* syndrome type, the TCM doctor needs to use the *supplementary* acupuncture method. In contrast, when the human belongs to *excess* syndrome type, we choose the *draining* acupuncture method. The key point of TCM treatment is to reach a balance in the *Yin*, *Yang*, *Deficiency*, and *Excess* of the human body."[3] As a result, the acupuncture method is essential for therapeutic effect. Based on the theory of *Lingshu*, several kinds of acupuncture methods have been developed to produce *supplementation* and *draining* effects for treatment.[3–5] One of the manipulations is directional *supplementation* and *draining*. It means that the *supplementation* is inserting the needle in the same direction of the meridian, while the *draining* is inserting the needle against the direction of the meridian.[4] In Chinese studies on animal subjects, the *supplementation* and *draining* manipulations were found to have different effects.[6–8] Research found that the manipulation group showed better therapeutic effects than simple acupuncture without manipulation.[9] Although the basis of TCM theory and some researchers note that *supplementation* and *draining* are important for therapeutic

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effect, the evidence of acupuncture manipulation is insufficient in current research.[10] Besides, research regarding the effect of directional manipulation of acupuncture on analgesic effects is controversial.[11]

Previous research found that the meridian has the electric characteristics of low impedance and high electric current.[12] There are different impedances between the surface of the skin and the low impedance sites adjacent to the acupoint and meridian, which are called *ryodoraku*.[13] It has been found that there is clear low-frequency electrical energy transmission on the meridian, as compared to a non-meridian site.[14] There are abundant ions, especially calcium ions, near the acupoint, which may be related to the electricity of the meridian.[15] Based on the electricity of the meridian, a recent study applied different electric pulses (pulse and alternating current) on the acupoint to measure the variance in electric current and found the phenomenon of meridians is similar to physics and electricity theories.[16] Moreover, the direction of meridians was observed according to the response electric current of the meridians.[17]

Due to the lack of sufficient research on the *supplementation* and *draining* manipulation, we have designed a study to investigate the electrical characteristics of the directional *supplementation* and *draining* manipulations, and believe that further clarity may be useful to research on acupuncture.

2. Method

2.1. Ethics approval

The study was approved by the Human Ethics Committee of Chang Gung Medical Foundation Institutional Review Board (201901601A3). The time of research was January 1, 2020, to December 31, 2020. All participants completed informed consent forms before participation in this study. All personal information and examination results were kept confidential by the principal investigator. We used a research number for anonymity for all participants in this study. The study has been registered at ClinicalTrials.gov (Identifier: NCT05261919).

2.2. Subjects

Participants were recruited from those considered healthy and at least 20 years old who agreed to the informed consent. The exclusion criteria for this study were as follows: those under 20 years old, pregnant or breast-feeding women, those with an empty stomach before the study, a tendency toward bleeding with thrombocytopenia or platelets <20,000, or a user of an anti-platelet drug. We used G*Power 3.0.1.0 software to calculate our sample size, with power = 0.8, alpha = 0.05, effect size convention $r = 0.9$. We recruited a total of 10 participants (5 male and 5 female), with ages between 20 and 30 years old.

2.3. Study design

This is an observational, crossover design, pilot study. This study was conducted at the Institute of Physics at National Sun Yat-sen University from January to December 2020. The participants were recruited from the students or staff at National Sun Yat-sen University and Kaohsiung Chang Gung Memorial Hospital. All the participants received both acupuncture manipulations (*supplementation* and *draining*) at the acupoints and were measured electric characteristics by an Agilent B1500A semiconductor analyzer. Our data values were paired measurements between *supplementation* and *draining*. We compared the electric characteristics of different acupuncture manipulations. The measurements were completed in one session and did not require a follow-up. The study diagram is depicted in Figure 1.

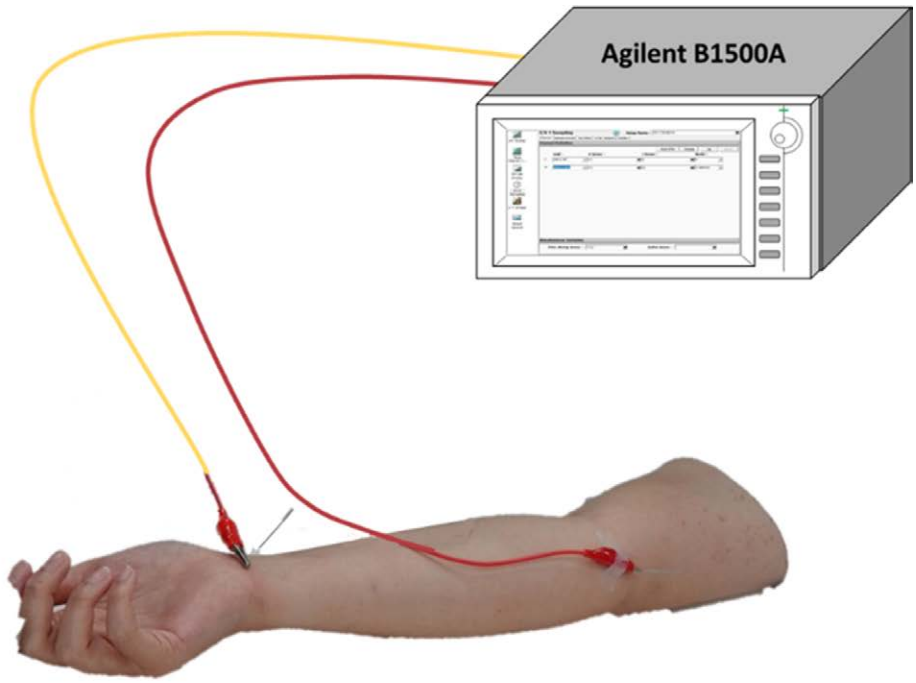

Figure 1. Schematic experimental setup of our study. Participants receive acupuncture first followed by measurements using an Agilent B1500A semiconductor analyzer connected to the needles and providing electric output to measure the electricity of meridians.

2.4. Acupuncture and manipulation methods

We choose 4 meridians: heart meridian (HT), small intestine meridian (SI), bladder meridian (BL), and kidney meridian (KI) in our study. The acupoints in our study were HT7, HT3, SI5, SI8, BL57, BL40, KI3, and KI10. The acupoints are shown in Figure 2A. All of the acupoints were selected and localized according to the guidelines of the WHO standardized acupuncture point location.[18] In TCM theory, the direction of meridians is from small to large numbers according to the WHO standardized acupoint number.

Acupuncture manipulation: The acupuncture manipulation is performed by a professional TCM doctor. We used directional *supplementation* and *draining* manipulations.[4] We defined *supplementation* as the angle of needle insertion to skin as 45 degrees with the needle tip in the same direction as the meridian. In contrast, *draining* is defined as the angle of needle insertion at 45 degrees with the needle tip direction opposite to that of the meridian. A schematic for *supplementation* and *draining* manipulations in our study is shown in Figure 2B.

2.5. Assessment method

We use an Agilent B1500A[16] semiconductor analyzer (Fig. 1) which can provide several kinds of direct and alternating current on the meridian, and then detect the changes in electric current, impedance, and voltage during the acupuncture.

This study uses 2 kinds of electric output, pulse, and alternating current, to measure the electric characteristics of the meridian. The pulse is a continuous square wave with voltage from 0 to 0.5, while the alternating current is a continuous square wave with voltage from –0.5 to 0.5. All the electric output can be generated at 4 frequencies (2Hz, 4Hz, 6Hz, and 8Hz).

2.6. Study procedures

The participants who met the inclusion criteria and completed the consent form were enrolled in the experiment. The time of the experiment was between 1:00 and 5:00 PM, with ambient room temperature ranging between 25°C and 28°C. The participants were seated comfortably in a chair during the acupuncture.

All the participants received *supplementation* manipulation first, followed by a measurement of the electrical characteristics by Agilent B1500A. We removed the acupuncture and then inserted the acupuncture needle using *draining* manipulation, followed by measurements. After one meridian measurement was completed, we removed the needle and proceeded to the next meridian to repeat the same procedure as described above. We measured HT, SI, BL, and KI meridians in sequence. The participants could finish the measurement in one afternoon without the need for follow-up.

2.7. Data analysis

The electrical characteristic of the 4 meridians was presented by mean ± standard deviation. We performed a paired *t* test analysis and repeated measure 2-way analysis of variance (ANOVA)

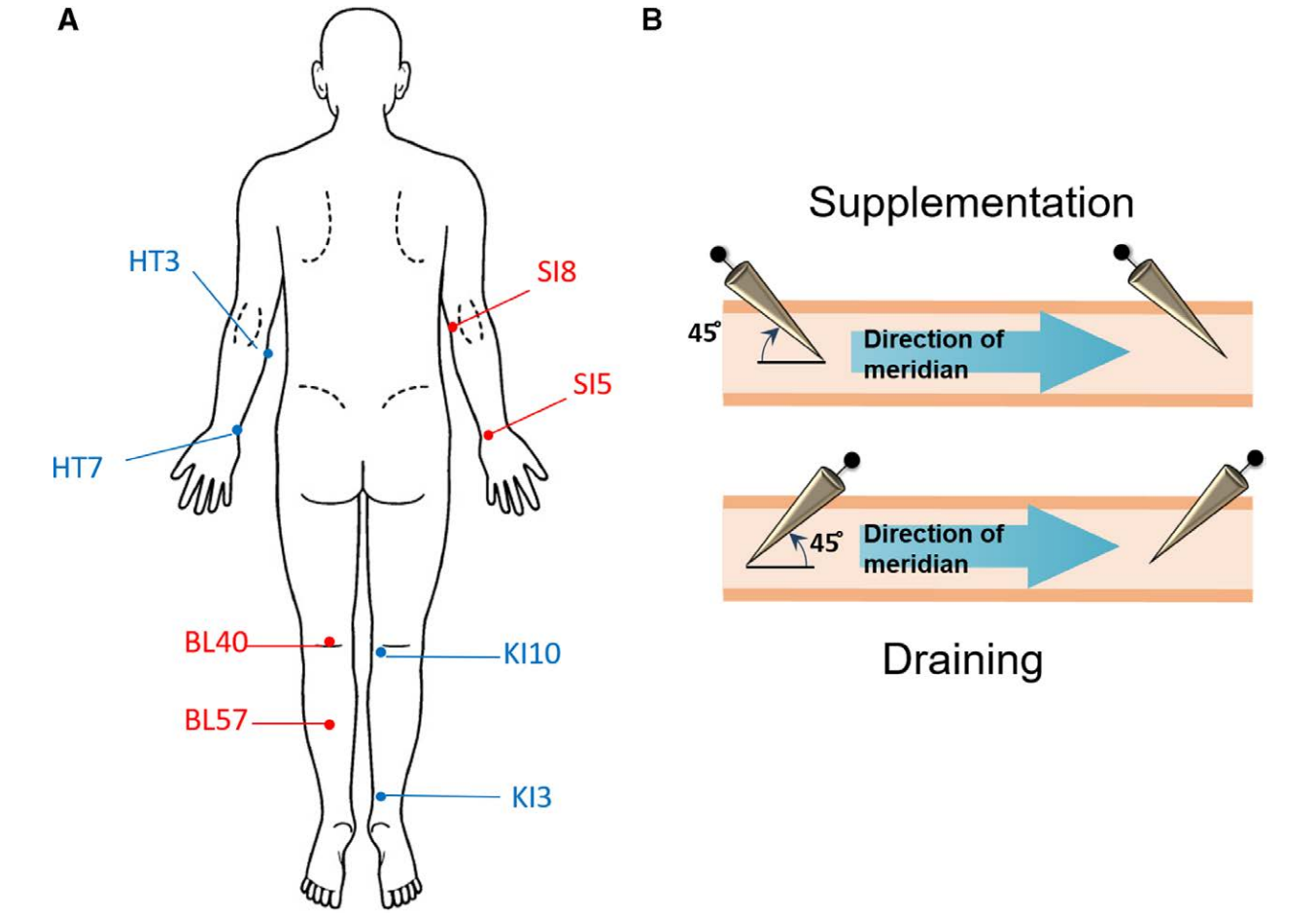

Figure 2. (A) The acupoints involved in this study. (B) Schematic diagram showing the *supplementation* and *draining* manipulations. We defined *supplementation* as the angle of needle insertion to skin as 45 degrees with the needle tip in the same direction as the meridian. In contrast, *draining* is defined as the angle of needle insertion at 45 degrees with the needle tip direction opposite to that of the meridian.

to compare the electric characteristics between these 4 meridians and different acupuncture manipulations. We performed multiple testing using the false discovery rate approach with the Benjamini and Hochberg method to correct the p value. Statistical significance will be considered at a P value of <.05. All statistical analyses were performed with SPSS for Windows, version 22 (Statistics 22; SPSS, IBM Corp., Chicago, IL).

2.8. Data monitoring

If the participants feel uncomfortable during the experiment, they can withdraw immediately and the reason for dropping out will be recorded. This study used acupuncture with electric stimulation, and similar previous studies did not report obvious or severe side effects of acupuncture or electroacupuncture.[18] The main complications of acupuncture are pain, bleeding, or dizziness,[20] and monitoring of this procedure was performed by a professional TCM doctor. As a result, the incidence of side effects of acupuncture is very low. In addition, the level of electrical stimulation is quite low in our study. Most participants do not feel any obvious electric stimulation or painful feeling during the experiment.

3. Result

3.1. The measured electric current of participants (Table 1)

The measured electric current measurements of 4 meridians with different acupuncture manipulations, those of *supplementation* and *draining*, are listed in Table 1. All of the electric current measurements are larger in *supplementation* manipulation when compared to *draining* manipulation in HT, SI, BL, and KI meridians.

Table 1

The measured electric current of participants (n = 10) (×10^{-7} unit).

	HT	SI	BL	KI
Supplementation				
Number/sex				
1/M	1.36	1.80	1.91	1.18
2/M	3.24	2.46	2.95	2.09
3/F	4.20	1.35	8.28	3.84
4/F	1.38	1.79	4.64	1.51
5/F	1.46	2.50	2.96	0.343
6/F	1.32	1.44	3.67	0.687
7/M	1.54	1.60	1.87	0.970
8/M	0.881	3.27	1.98	4.77
9/M	1.13	1.45	3.15	1.93
10/F	2.05	2.06	1.53	0.845
Draining				
Number/sex				
1/M	0.788	0.999	1.29	0.755
2/M	1.64	1.70	1.05	1.40
3/F	2.80	0.492	5.20	3.27
4/F	0.887	1.34	0.861	0.409
5/F	0.885	0.542	0.582	0.257
6/F	0.391	0.245	0.588	0.273
7/M	1.28	1.04	0.335	0.621
8/M	0.589	2.00	1.02	1.66
9/M	0.582	0.991	2.68	1.19
10/F	1.56	1.31	1.03	0.472

Values are expressed as above with unit ×10^{-7}.

BL = bladder meridian, F = female, HT = heart meridian, KI = kidney meridian, M = male, SI = small intestine meridian.

3.2. Comparison of subjects' electric current during different acupuncture manipulations and at different meridians (Table 2)

We analyzed the electric current by mean and standard deviation and compared the difference between meridians and acupuncture manipulation (Table 2). The overall measured electric current for the 4 meridians showed a statistical difference between *supplementation* and *draining* manipulations (P < .001). The overall measured electric current in the same manipulation methods did not show a statistical difference between meridians (P = .094).

The mean and standard deviation of the electric current at meridian HT are 1.86 ± 1.05 and 1.14 ± 0.72, respectively, in *supplementation* and *draining* manipulations with a statistical difference (P = .001). The mean and standard deviation of electric current in meridian SI are 1.97 ± 0.61 and 1.07 ± 0.55, respectively, in *supplementation* and *draining* manipulations, indicating a statistical difference (P < .001). The mean and standard deviation of electrical current in meridian BL are 3.29 ± 2.00 and 1.46 ± 1.46, respectively, in *supplementation* and *draining* manipulation with a statistical difference (P = .001). The mean and standard deviation of electric current in meridian KI are 1.82 ± 1.43 and 1.03 ± 0.92, respectively, in *supplementation* and *draining* manipulation, indicating a statistical difference (P = .018). In the same manipulation, the comparison of electric current between different meridians showed no statistical difference (P = .060 and P = .488 respectively) in *supplementation* and *draining* manipulations.

3.3. The comparison of male subjects' electric current for different acupuncture manipulations and meridians (Table 2)

The overall measured electric current in 4 meridians showed statistical difference between *supplementation* and *draining* manipulations (P = .007). The overall measured electric current in the same manipulation methods did not show statistically difference between meridians (P = .684). Using reporting similar to above, the means and standard deviations of electric current for *supplementation* and *draining* manipulations are 1.63 ± 0.93 and 0.98 ± 0.47 for meridian HT (P = .074); 2.12 ± 0.75 and 1.35 ± 0.47 for meridian SI (P = .021); 2.37 ± 0.62 and 1.28 ± 0.86, for meridian BL (P = .031); and 2.19 ± 1.52 and 1.13 ± 0.44 for meridian KI (P = .109). For the same manipulation, a comparison of electric current between different meridians showed no statistical difference (P = .656 and P = .656, respectively) in either *supplementation* or *draining* manipulations.

3.4. The comparison of female subjects' electric current for different acupuncture manipulations and meridians (Table 2)

The overall measured electric current in 4 meridians showed a statistical difference between *supplementation* and *draining* manipulation (P = .002). The measured electric current for the same manipulation showed no statistical difference between meridians (P = .155). For female subjects, using reporting similar to above, the means and standard deviations of electric current for *supplementation* and *draining* manipulations are 2.08 ± 1.22 and 1.30 ± 0.93 for meridian HT (P = .021); 1.83 ± 0.47 and 0.79 ± 0.51 for meridian SI (P = .021); 4.22 ± 2.54 and 1.65 ± 1.99 for meridian BL (P = .021); and 1.45 ± 1.40 and 0.94 ± 1.31 for meridian KI (P = .038). In the same manipulation, a comparison of electric current between different meridians showed a statistical difference (P = .038) in the *supplementation* manipulation but no statistical difference in the *draining* manipulation (P = .406). However, we further

Table 2

Comparison meridian and sex of subjects electric current in different acupuncture manipulation (×10^{-7} unit).

	Supplementation (n = 10)	Draining (n = 10)	*P* value for manipulation	*P* value for meridian
Overall			<.001*	.094
Meridian				
HT	1.86 ± 1.05	1.14 ± 0.72	.001*	
SI	1.97 ± 0.61	1.07 ± 0.55	<.001*	
BL	3.29 ± 2.00	1.46 ± 1.46	.001*	
KI	1.82 ± 1.43	1.03 ± 0.92	.018*	
P for meridian	.060	.488		
Male			.007*	.684
HT	1.63 ± 0.93	0.98 ± 0.47	.074	
SI	2.12 ± 0.75	1.35 ± 0.47	.021*	
BL	2.37 ± 0.62	1.28 ± 0.86	.031*	
KI	2.19 ± 1.52	1.13 ± 0.44	.109	
P for meridian	.656	.656		
Female			.002*	.155
HT	2.08 ± 1.22	1.30 ± 0.93	.021*	
SI	1.83 ± 0.47	0.79 ± 0.51	.021*	
BL	4.22 ± 2.54	1.65 ± 1.99	.021*	
KI	1.45 ± 1.40	0.94 ± 1.31	.038*	
P for meridian	.038**	.406		

Values are expressed in mean ± standard deviation.

ANOVA = analysis of variance, BL = bladder meridian, HT = heart meridian, KI = kidney meridian, SI = small intestine meridian.

*$P < .05$.

**$P < .05$, but *post hoc* comparisons indicate that no significant differences exist. Repeated measure 2-way ANOVA and paired *t* tests were used to analyze the differences between different meridians and acupuncture manipulation directions. The *P* value was calculated and corrected by using the false discovery rate from Benjamini and Hochberg.

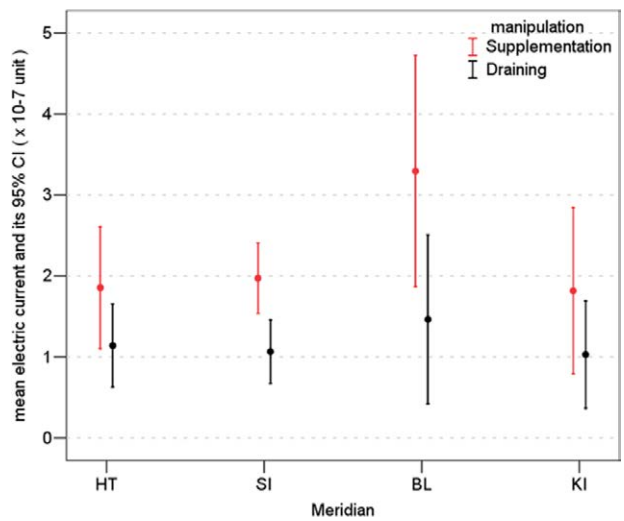

Figure 3. The primary outcome of our study. The mean electric current and its 95% confidence interval for *supplementation* and *draining* manipulations in different meridians are shown above.

used *post hoc* testing to compare other meridians, and it shows no significant difference between these 4 meridians for the female group.

3.5. The mean electric current and its 95% confidence interval for supplementation and draining manipulations for 4 meridians (Fig. 3)

An error bar graph showing the difference between manipulation method results is presented in Figure 3. The error bar shows the difference in mean electric current and its 95% confidence interval for the *supplementation* (red line) and *draining* (black line) manipulation for the 4 meridians. There is a clear difference in electric current for *supplementation* and *draining* manipulations. The mean electric current of the *supplementation* manipulation is near parallel to the *draining* manipulation with a standard deviation near 1 × 10^{-7} units for the 4 meridians.

4. Discussion

We found that meridians have physical properties in this study. The main finding of the present study is that there is a significant difference in electric current between *supplementation* and *draining* manipulations performed during acupuncture. The electric current is significantly larger in *supplementation* manipulation compares to *draining* manipulation in the 4 meridians. This result is also observed in different meridians. The manipulation affects the electric current rather than the different meridians.

In the data collected from participants (Table 1), all of the electric current measurements are larger in *supplementation* manipulation when compared to *draining* manipulation for the same participants and meridians, regardless of sex. In previous research, the electrical activity of the meridians was positively associated with *qi*, the concept which is the indicator of physiologic energy in TCM theory.[21] *Supplementation* manipulation can increase *qi* while the *draining* manipulation can decrease *qi* in TCM theory.[3] Our study showed that directional manipulation can affect the electric current such that the electric current is larger in *supplementation* manipulation and smaller in *draining* manipulation, corresponding to TCM theory.

In our study, there is a significant difference between *supplementation* and *draining* manipulations among the 4 meridians, HT, SI, BL, and KI in Table 2. The graph of the error bar (Fig. 3) shows that the *supplementation* manipulation is near

parallel to the *draining* manipulation, which indicates that the manipulation results in different electric currents in the human body. Acupuncture manipulation is an important factor in therapeutic effects which regulate the flow of *qi* in TCM theory.[3] In a Chinese study, *supplementation* manipulation can activate the meridian and increase physiologic energy while *draining* manipulation can inhibit the meridian and decrease physiologic energy.[7] *Ryodoraku*, which is found by Nakatani and Yamashita, was a device to measure the energy in the meridians.[2] The mechanism of *ryodoraku* is measuring the change in micro-electrical current in the meridian and the energy of the meridians is positive correlative to the measured electric current; the lavish energy means large electric current in physics and *excess* syndrome in TCM theory while insufficient energy means lower electric current and *deficiency* syndrome in TCM theory.[6] In our study, the *supplementation* manipulation produced a larger electric current while that of *draining* manipulation was lower. This result corresponds to the TCM theory and the meridian energy in the *ryodoraku* study.

Although the mechanism of differences in electric currents between manipulation is not currently known, previous studies showed that physical manipulation can affect the therapeutic effect.[22] In terms of electricity at a meridian, the research found that the electric current is probably caused by ions flowing in the meridian.[12] Research also found that the meridian has a slight electric current in resting state, which is called ion diffusion, and the electric current increases when there is the same electric current generated by charge, which is called ion drift.[16] In physics, the current density is positively correlated to carrier concentration, the quantity of electric charge, and drift velocity, rather than the direction of needling.[16] Hence, it is not reasonable to produce a different electric current in the electric circuit by changing the direction of the electrode. We speculate that there are more ions produced in the *supplementation* manipulation, which can further produce more carrier concentration, resulting in a larger electric current. In contrast, in the *draining* manipulation, the ion production is lower and results in lesser carrier concentration and electric current. This supports the supposition that the direction of the needle controls the ion production during *supplementation* and *draining* manipulations, according to our result.

In the *supplementation* and *draining* manipulation, there are no statistical differences between different meridians. In TCM theory, the activation or inhibition effect on meridians is positively correlated to the manipulation method rather than the specific meridian.[7] Our result is consistent with TCM theory. Considering differences between male and female participants, both groups showed that the acupuncture manipulation produced significant differences between *supplementation* and *draining* while the same manipulation at different meridians did not. However, the male group showed that there was no difference between *supplementation* and *draining* manipulations on HT and KI meridians. In TCM theory, meridian activity is associated with *supplementation* and *draining* manipulations rather than sex or meridians.[7] Although some research revealed that sex differences may result in a different response in acupuncture,[23,24] there is currently no study about the difference in response for manipulations related to sex or meridians. This result may be related to either the small sample size in our study or potential differences in acupuncture responses for different manipulations, meridians, and sex. Further study may be needed to investigate this issue. Moreover, in the same *supplementation* manipulation, the female group showed significant differences between meridians. However, further used *post hoc* tests indicate no significant differences between each of these 4 meridians. As a result, there is still no electric current difference that can be determined between meridians in the female group.

The major strength of this investigation is that it is the first study to investigate the direction of acupuncture manipulation on humans. There are significantly different electrical effects between *supplementation* and *draining* manipulations, which suggests that there may be a difference in effect with manipulation and that the TCM theory of manipulation may have clinical significance, and should be taken into consideration in future studies. However, there are some limitations in this study. First, the sample size of our pilot study is small, and we only investigate the electric characteristic of 4 meridians. A larger sample size and a thorough study of twelve meridians are needed to fully investigate the effect of directional manipulation. Second, our study discusses the effects of directional *supplementation* and *draining* manipulations on electrical characteristics. As a result, the directions of the needle are *supplementation* and *draining*. Therefore, we can design the needle insertion with a vertical angle as a control group for a more thorough investigation of the electric current between vertical angle, directional *supplementation,* and *draining* manipulation. Third, our study aims to explore the electric characteristic of the manipulation. The relationship between electrical differences and clinical effect or the mechanism of manipulations is not clear in our study. Further study is needed to investigate the relationship between clinical effect and the electric current in the meridian as well as the mechanism of manipulation.

5. Conclusion

Our study found that there are differences in the electric characteristics between directional *supplementation* and *draining* manipulations. The *supplementation* manipulation produced a larger electric current, while the *draining* manipulation had a smaller electric current. Our findings suggest that the type of directional manipulations can result in different effects and may have clinical significance. Further study may be needed to investigate the relationship between electrical differences and clinical effects depending on manipulation.

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Author contributions

YCH and TCC conceived, designed, and planned the study. WCC, YFT, CWK, and CHL are recruiting the study participants and performing the interventions. TCC and YCH supervised the study. CCW, TMT, STT, WLH, and CHL interpret and analyze the data. YFT and CHL drafted the manuscript. YCH critically revised the manuscript for important intellectual content. All authors have full access to the manuscript and take responsibility for the study design. All authors have approved the manuscript and agree with the submission.

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