American Journal of Chinese Medicine, Vol. 28, No. 1, pp. 41–55

Effect of Acupuncture at Hsien-Ku (St-43) on the Pulse Spectrum and a Discussion of the Evidence for the Frequency Structure of Chinese Medicine

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(Accepted for publication November 19, 1999)

Abstract: We investigated the pulse spectrum variation of the human radial artery when Hsien- Ku (St 43), an acupoint on the stomach meridian, was needled and compared the results with the acupuncture effects of two other acupoints, Tsu-San-Li (St-36) and Tai-Shih (K-3), reported previously. For Hsien-Ku, the harmonic proportions were redistributed: the second harmonic (C2) decreased, C3, C5, C6, C7, C8 and C9 increased, C3, C6 and C9 became the relative peaks to their neighboring harmonics and C2, C4 became the relative minimums. The phase angles of the 2nd harmonic (P2) and 5th harmonic (P5) decreased, propagating faster. These effects were similar to that of Tsu-San-Li which is also on the stomach meridian. A totally different pattern was found for Tai-Shih on the kidney meridian. These results strengthen the theory that a meridian can be classified according to its effects on the pulse spectrum, and that all the meridian related effects such as those caused by acupuncture or meridian specific herbs are frequency specific.

In the past decades more and more evidence elucidates the therapeutic effects of Chinese medicine (Mann, 1990; Kao, 1992); the reasons behind this curing capability become urgent so that they may be applied to the general public for universal benefit. Many scientists have worked on the physiological basis of Chinese medicine such as pulse diagnosis (Yoon *et al.*, 1987), acupuncture points (Plummer, 1980), meridians (Zhu *et al.*, 1986; Lazorthes *et al.*, 1990; Jong *et al.*, 1992) etc.; but little progress has been made during the last decade.

Since 1987 we have developed the resonance theory (Wang *et al.*, 1987, 1989a,b,c; Wang Lin *et al.*, 1991). Both the electrical analogue model (Wang *et al.*, 1989a, 1992; Wang Lin *et al.*, 1991) and the hemodynamic model with radial dilatation describe the behavior for a real artery (Wang Lin *et al.*, 1997). All these merged into the pressure wave propagation equation and the resonance conditions or the coupled-oscillation system. Coupling models were derived further in 1994 (Wang *et al.*, 1994b) to solve the coupling between artery and different arterial trees. These provide a systematic physiological basis for studying the Chinese medicine system. The following are our suggestions:

(1A) The artery tree of each organ links with the main artery to form a coupled oscillation system resonating with a specific frequency or frequencies generated by the heart.

(1B) Physically, an acupuncture point is a small anatomic unit, which contains nerve entry to muscles (motor point) and a group of small blood vessels (arterial tree) around it. According to resonance theory, this group of small blood vessels will behave as one mechanical unit coupled with the main artery in circulatory system (Wang *et al.*, 1989b,c, 1994a). This provides this small circulatory unit a key function as acupoint. One meridian is a hypothetical or functional line linking these arterial trees (acupoints) with similar resonance property. In this weakly coupled system, there are two resonant frequencies in the acupuncture point and only one in the artery. The meridian selected frequency may be the same as the resonant frequency of its related internal organ.

The resonant mechanism seems to be the key to understanding Chinese medicine if the frequency mystery of each meridian is classified.

(1C) From the pressure wave propagation equation, the resonance frequency of the organ (or tissue)-main artery coupled system will decide the blood pressure energy distribution. Since the resonance characteristics of this coupled system are determined by its physical properties, any physical disturbance to either the organ (tissue) or the artery will redistribute the blood pressure energy and therefore influence the blood distribution (Wang *et al.*, 1994b). The heart output of a 70Kg adult is about 1.7Watt (Milnor, 1989). Assume that the internal organs get about half of this energy and the rest of the body (about 360 acupoints around) get the other half, the energy for each acupoint is only about (0.8Watt/360) $\cong$ 0.002Watt. Compared to this small energy, needling an acupoint will be a very large disturbance to cause an impedance mismatch and therefore influence the efficiency of resonance. Stimulating an acupuncture point, which is a tissue rich with small arteries, is an effective way to cause the redistribution of blood pressure energy and therefore influence the blood distribution.

To explore the frequency nature of Chinese medicine as described above, we have put in a lot of effort. Every finding has made the theory more solid. Some of our results are listed below:

(2A) We simulated a system of an artery with a side branch organ in 1994. Multigenerational elastic tubes with small holes at the terminal to mimic the openings of arterioles were constructed to simulate an organ. A resonating system will be formed for certain physical structures and the pressure distribution in this simulated system can be described by the pressure wave propagation equation and the coupled oscillation equation (Wang *et al.*, 1994b).

(2B) By pressing an acupoint, we found that the blood pressure energy was redistributed but there was no effect if a nonacupoint was pressed. The size of the blood pressure pulse (systolic pressure-diastolic pressure) decreased significantly when it was measured from an artery along the meridian of the acupoint that had been pressed regardless of whether the measured point was above or below the pressed point. There was little pulse size decrease if the blood pressure was measured on an artery along a different meridian. Furthermore, the effects on the spectrum were meridian-artery specific (Wang *et al.*, 1989c). Pressing acupoints on different meridians caused different variation patterns. The pressure pulse spectrums measured on different arteries along different meridians were different as well.

Experiments were conducted to show that redistribution of the blood pressure energy would also influence the blood flow distribution.

Using the simulating system described above, we found that the net flow through the simulated openings is proportional to the amplitude of the harmonic wave but independent of its frequency (Wang *et al.*, 1994b).

The blood velocity at some acupoints on the human body surface was measured by laser-Doppler technique and herbs such as Panax ginseng were used to disturb the pressure pulse. We found that the corresponding pressure and the blood velocity variations were highly correlated (Wang *et al.*, 1994b).

The needling effect on the microcirculation blood flux was also studied. The mean flux at an acupoint decreased significantly when it was on the same meridian as the needled acupoint. There was little decreasing if the mean flux was measured on a different meridian (Chen, 1998). This study is comparable to the above described effects of pressing acupoints, which showed the intensity of the pressure wave was decreased in a similar way.

Our recent study of the relation between rat renal cortical flux and the abdominal aortic blood pressure shows that the driving efficiency is higher (flux to pressure area ratios) for a higher pulsatile blood pressure; this drives more microvascular blood flux (Jan *et al.*, paper in print).

(2C) To search for the resonance frequencies of each organ-meridian, both animal experiments (Young *et al.*, 1989, 1992; Yu *et al.*, 1994) and human clinical tests (Chen *et al.*, 1993; Wang *et al.*, 1996c; Lu *et al.*, 1996) were conducted. Measuring human pressure pulses on different arteries at different body locations, we found that amplitude of different harmonics of the pulse spectrum will be enhanced. The amplitude of the 2nd harmonic (C2) will be enhanced on the foot arteries, the amplitude of the 6th harmonic (C6) will be enhanced on head, and the amplitude of the 4th harmonic (C4) will be enhanced on hand (Wang *et al.*, 1989b). Clamping the artery supplying an internal organ in animal experiments allowed the study of organ-frequency relationships. The pressure spectrum variations showed that the 1st harmonic wave is the major driving force for blood to flow into the liver, the 2nd harmonic wave is for the kidney and the 3rd is for the spleen (Wang *et al.*, 1989a; Young *et al.*, 1989, 1992; Yu *et al.*, 1994). We have checked the pulse spectrums of the clinical patients with possible liver problems (Lu *et al.*, 1996) and chemical factory workers with abnormal blood test (Wang *et al.*, 1996c). The spectrum differences between the healthy controls and these abnormal persons were consistent with the frequency specificity of the organ.

In addition, the organ-frequency relations of the heart (DC term of the pulse), lung (the 4th harmonic), stomach (the 5th harmonic), gall bladder (the 6th harmonic), bladder (the 7th harmonic), large intestine (the 8th harmonic) were inferred from several indirect approaches. For example, we have investigated the pressure spectrums of patients with acute uncomplicated myocardial infection (Chen *et al.,* 1993) which indicated the heart-C0 (DC term of the pulse) relations.

From non-linear phenomena such as 2nd harmonic generation and the sum-frequency rule, we may deduce the five element theory as well as the creating and destroying rules in Chinese medicine, which are also important clues in inferring organ-frequency relations (Wang *et al.*, 1989c).

(2D) Many meridian related herbs such as Rhizoma Coptidis, Radix Bupleuri, Rehmannia glutinosa, Cornus officinalis, Ganoderma lucidum, Panax ginseng, American ginseng ... and so on have been studied (Wang *et al.*, 1994a,b, 1995b, 1997, 1998; Wang Lin *et al.*, 1992). Their effects on the Fourier components of the pressure pulse indicate that the classification of the meridian related herbs is frequency specified. The effects also provide evidence for the organ-frequency relations we inferred above. As examples, for the herb treated rats, Rhizoma Coptidis decreased the DC term of the pulse C0 (heart loading) and the amplitude of the 1st harmonic C1 (liver). Radix Bupleuri increased C1 (liver) but decreased C2 (kidney) (Wang Lin *et al.*, 1992). Rehmannia glutinosa increased C2 (kidney) and C3 (spleen) but decreased the C0 (heart loading), C4 (lung), C5 (stomach), C6 (gall bladder), C7 (bladder) (Wang *et al.*, 1998). In human studies, C3, C6, C9 were increased extensively for subjects treated with Ganoderma lucidum. Panax ginseng and American ginseng both decreased C2 but increased C4 (lung), C5, C6, C7, C8, C9 with C4 and C7 as relative peaks (Wang *et al.*, 1994).

(2E) This is the third report in the acupuncture series (Wang *et al.*, 1995a, 1996a). Previously, we found that there were different frequency responses when needling acupoints on different meridians. According to the wave propagation equations, the phase change is very sensitive to the resonance frequency (Wang Lin *et al.*, 1991,1997; Wang *et al.*, 1992, 1994b). The phase variation of the pressure wave spectrum during a physical disturbance may allow an inference as to the resonance frequency of the affected tissue. Acupuncture may stiffen the tissue and therefore the pressure wave will travel faster. This will be observed as a negative change of the phase angle at the resonance frequency. The phase angle of the 5th harmonic was decreased significantly when Tsu-San-Li (St-36) on the stomach meridian was acupunctured (Wang *et al.*, 1995a) and the phase angle of the 2nd harmonic was decreased significantly when Tai-Tsih (K-3) on the kidney meridian was acupunctured (Wang *et al.*, 1996a). The resonance frequencies detected by the phase angle responses are consistent with the resonance frequencies of the meridian and its related organ. The amplitude responses are also found to be the right indicators of their traditionally postulated therapeutic effects; each acupoint has its distinct pattern.

The needling effect on the pulse spectrum is highly reproducible. We will have the similar effect by needling the same acupoint no matter on the same or a different subject. If each of the repeating effect patterns had happened randomly and were not physically determined, the percent difference of the harmonic proportion or the phase difference of any harmonic could either be larger or smaller than zero; there is only a 1/2 chance for either case. This means there is only a 1/2 chance that the percent differences of the harmonic proportion of the 1st harmonic for two random effects will be both larger (or smaller) than zero. Similarly, there is 1/2 chance that the percent differences of the harmonic proportion of the 2nd harmonic will vary in the same direction and so on. Since the Fourier component is an orthonormal system (i.e. each one is independent), there is a $(1/2)^9$ (the 9 comes from 9 harmonics) chance that the percent differences of the harmonic proportions of all nine harmonics will vary in the same direction, and $(1/2)^9$ that the phase differences of all nine harmonics will vary in the same direction. Since the percent differences of harmonic proportion and the phase difference are independent variables, the possibility for two repeating effects will be $(1/2)^9 \times (1/2)^9 \approx 3.8 \times 10^{-6}$. That is if each of the repeating effect patterns were not physically determined but happened randomly, the chance likelihood of such reproducibility is only about 3.8×10^{-6}. Could the nervous system be the physical cause of these effects? We can not find in the literature or imagine a mechanism by which autonomic reflexes or other autonomic neural mechanisms could cause such highly specific effects.

In this report, to further insure these frequency responses are indeed meridian related and not due to non-specific autonomic reflexes, the effects of two acupuncture points that are near each other on the same meridian (Hsien-Ku, St-43 and Tsu-San-Li, St-36, both on the stomach meridian) were compared. The data for Tsu-San-Li were collected in an earlier study (Wang *et al.*, 1995a) and only Hsien-Ku was stimulated in the present experiments. Since acupuncture points on the same meridian have similar therapeutic effects, they might be expected to have similar effects on the frequency spectrum of the arterial pulse. These effects should follow the resonance equation and be meridian specific as well.

Material and Method

1. Subjects

Twenty two healthy subjects, 10 males, 12 females, 20 to 55 years of age were tested. All subjects were asked not to take any medication for 3 days before the experiments. During the test day, they were not allowed to have any alcoholic or caffeinated beverages. Every subject was food restricted at least one hour before experiment. A half-hour rest was routinely required before the test. Room temperature was kept between 23°C and 25°C.

2. Experimental procedure

The experimental setup was similar as described in our previous report (Wang *et al.*, 1995a, 1996b). Briefly, each subject was asked to sit down. The right hand radial artery pressure pulse was recorded with a pressure transducer (PSL-200GL, Kyowa Electronic Instrument Co. Ltd. Japan) that was fixed on the skin by scotch tape and an adjustable belt with a small button to give suitable pressure on the transducer. The criterion of a good measurement was the largest amplitude pulse. Six consecutive pressure pulses were taken as control. An acupuncture needle was then inserted into Hsien-Ku (St-43). No special acupuncture treatment (manipulating the needle to increase or decrease "Chi") was done. Six pressure pulses were then taken at 10 seconds, 5 minutes, 10 minutes, 15 minutes after the needle was inserted and the same sequence was repeated after the needle was removed. The pressure transducer was left in place during the entire measuring process.

Control P(T0) →insert needle→10 seconds P(TNS)→5 minutes P(TN5)
→10 minutes P(TN10)→15 minutes P(TN 15)
↓
take out needle→10 seconds P(TOS)→5 minutes P(TO5)
→10 minutes P(TO10)→15 minutes P(TO15)

3. Data analysis

Output of the transducer was connected to an IBM PC via an A/D converter with sampling rate of 430Hz. Pulse spectrum was analyzed with Fourier transform using T(period)=l pulse.

Standard deviation of heart rate from the 6 pulses in a measurement was not allowed to exceed 5%. Every pulse spectrum measured at needle in and needle out periods was compared with the pulse spectrum measured during the control period. To keep the Fourier transform meaningful, we exclude measurements with heart rate differences exceeding 10% of control. Variations of pulse spectra between these comparison times were expressed as the percent differences of the harmonic proportions and the phase differences from harmonics 1 to 9. By this system analysis method, the spectrum variations will only depend on the system's characteristics and behave in the same way no matter what the heart input is.

Percent difference of the harmonic proportion of the nth harmonic between period Ti and control = [%Diff.-Cn(Ti)] = 100×[Cn(Ti)-Cn(T0)]/Cn(T0)

where Cn(T0) = (An/A0) at the control period

=harmonic proportion of the nth harmonic at the control period

Cn(Ti)=(An/A0) at period i

=harmonic proportion of the nth harmonic at period i

An : amplitude of the nth harmonic

A0 : DC value of the pulse spectrum

Ti : period i

T0: control period

Phase difference of the nth harmonic [Diff.-Pn(Ti)]=Pn(Ti)-Pn(T0)

where Pn : phase angle of the nth harmonic

4. Statistics

Similar statistics procedures were performed as we did for Tsu-San-Li, previously (Wang *et al.*, 1995a). The Diff.-Pn(Ti) and %Diff.-Cn(Ti) of all the subjects were averaged at each period Ti for harmonics 1 to 9. Acupuncture effects from Hsien- Ku were compared with the effects of a non-acupuncture point (Wang *et al.*, 1995b) and Student's t-tests for group comparison were done. The non-acupuncture point was located at the large empty place halfway between Cheng-Ching (B-56) and Yang-Lin- Chuan (G-34); it is not far away from Tsu-San-Li and is easy to needle reproducibly.

The needling effect of the non-acupuncture point was presented in our previous report (Wang *et. al.*, 1995a).

Results

Figure 1 shows the averaged acupuncture effects as the percent difference of the harmonic proportions (%Diff.–Cn(Ti)) for Hsien-Ku. Standard error of means and group comparison t-test results of N5 (needle-in, 5 minutes) and O5 (needle-out, 5 minutes) periods are also presented. Standard error of means were all similar in other periods. The t-test results of harmonic proportions between Hsien-Ku and the nonacupuncture point are shown in Table 1.

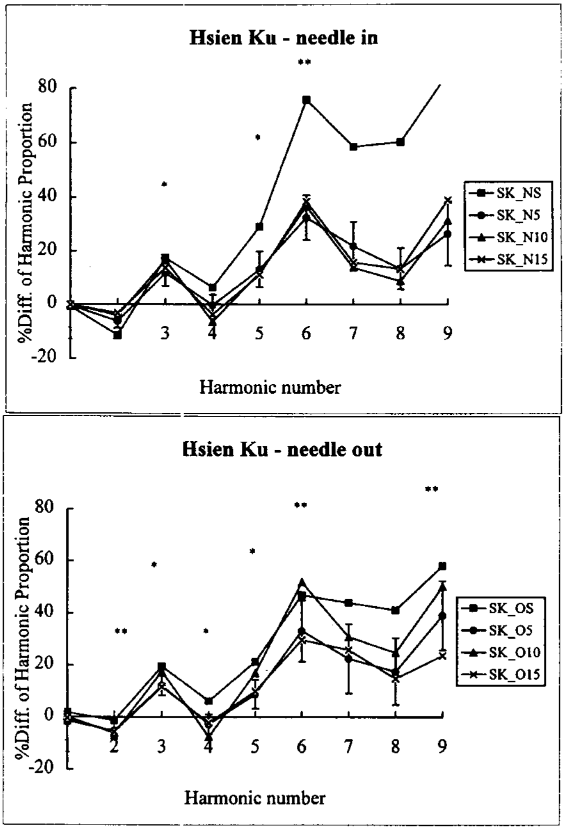

Figure 1: The acupuncture effect of Hsien-Ku. The percent differences of harmonic proportions are presented. The means ± SEM (the standard error of mean) of the second curve (period of SK_N5 of the top set, SK_O5 of the bottom set) were plotted as the vertical bars and the T-test results between the acupuncture Hsien-Ku group and the nonacupuncture point group for these two times are shown as * : P<(0.1), ** : P<(0.05), *** : P<(0.0 1)

Table 1. The T-test Result of the % Difference of Harmonic Proportions Between Acupuncture Hsien-Ku Group and the Nonacupuncture Point Group

	Ns	N5	N10	N15	Os	O5	O10	O15
C1								
C2	***					**	**	*
C3	**	*	**	**	**	*	***	
C4			**	*		*	***	
C5	**	*	**	**	***	*	***	***
C6	***	**	**	***	***	**	***	***
C7	*						*	
C8	***				**		**	*
C9	***		*	**	***	**	***	*

*P < (0.1) **P < (0.05) ***P < (0.01)

The energy of the pressure wave was redistributed after acupuncture at Hsien-Ku. The harmonic proportions of the 2nd harmonic (C2) were decreased. C3, C5, C6, C7, C8 and C9 were all increased. C3, C6 and C9 were the relative peaks to their neighboring harmonics. C1 was not affected. Average effects on phase differences (Diff.-Pn(Ti)) are shown in Figure 2. The statistical analysis is shown in Table 2. The phase angle of the second and the fifth harmonics (P2 and P5) decreased in almost all the experimental periods. At the NS period, the phase angle of several other harmonics also decreased significantly; however, the decay was not significant at most other periods. P2 and P5 were the relative minimum to their neighboring harmonics.

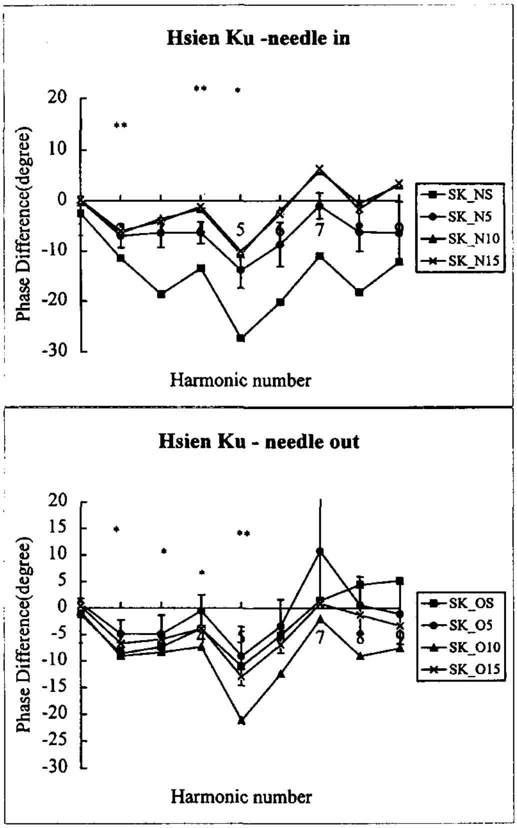

Figure 2: The acupuncture effect of Hsien-Ku. The differences of phase angle are presented. The means ± SEM (the standard error of mean) of the second curve (period of SK_N5 of the top set, SK_O5 of the bottom set) were plotted as the vertical bars and the T-test results between the Hsien-Ku and the nonacupuncture groups for these two times are shown as * : P<(0.1), ** : P<(0.05), *** : P<(0.0 1).

Discussion

The needle out effects of Tsu-San-Li (Wang *et al.*, 1995a), Tai-Tsih (Wang *et al.*, 1996a) and non-acupuncture point (Wang *et al.*, 1995a) are shown in Figures 3, 4 and 5. They can be compared with Hsien-Ku shown in Figures 1 and 2. From this we found:

Table 2. The T-test Result of the Phase Angle Difference Between Acupuncture Hsien-Ku Group and the Nonacupuncture Point Group

	Ns	N5	N10	N15	Os	O5	O10	O15
P1								
P2	***	**	**	**	***	*	***	***
P3	** *		*			*	**	*
P4	** *	**				*	***	***
P5	***	*	*	*	*	**	***	**
P6	***						*	*
P7	***							
P8	***						*	
P9								

*P < (0.1) **P < (0.05) ***P < (0.01)

(1) Similar patterns are shown for needling acupoints on the same meridian. Despite slight differences in statistical significance, the acupuncture effects of Tsu-San-Li and Hsien-Ku, both of which are on the stomach meridian and near each other, are similar. We can scale the similarity as follows, the two O5 curves shown in Figures 2b and 3b are compared as an example. The relative sequential values of each harmonic on these curves could be simplified as 1st>2nd–3rd<4th>5th<6th<7th>8th–9th. Considering that the phase difference of any harmonic could either be larger or smaller than its neighboring harmonics, there is only 1/2 chance for each case. It means that without counting the obscure relationship between the 2nd–3rd harmonics and the 8th–9th harmonics, there is 1/2 chance that the 2nd harmonic will be lower than the 1st one, 1/2 chance that the 4th harmonic will be higher than the 2nd–3rd ones, and so on. Since the Fourier component is an orthonormal system (i.e. each one is independent), the likelihood that two curves will occur with P1, P4, and P7 as the relative maximums (they are lager than their neighboring harmonics), and P5 as the relative minimum is $(1/2) \times (1/2) \times (1/2) \times (1/2) \times (1/2) \times (1/2) = (1/2)^6 \approx (1/64)$ at most.

High similarity could also be seen for the amplitude curves. The values of each harmonic on the O5 curves in Figures lb and 3a could be simplified as 1st > 2nd < 3rd > 4th < 5th < 6th > 7th – 8th < 9th. Without counting the obscure relationship between the 7th–8th harmonics, the likelihood that two curves will occur with C3, C6 and C9 as the relative maximums, and C2 and C4 as the relative minimums is $(1/2) \times (1/2) \times (1/2) \times (1/2) \times (1/2) \times (1/2) \times (1/2) = (1/2)^7 \approx (1/128)$ at most.

Since the phase and the amplitude are independent variables, there is only about a $(1/64) \times (1/128) = (2)^{-13} \approx 0.0001$ possibility that the O5 effects of Tsu-San-Li and Hsien-Ku shown in Figures 1b, 2b, 3a, and 3b occurred by chance alone.

(1a) The phase angle of the second and the fifth harmonics (P2 and P5) decreased; they were the relative minimum to their neighboring harmonics. From the resonance theory, this indicates that both of the acupoints have the same resonance frequencies, the second and the fifth harmonics. As we state in the *Introduction*, the amplitude of the 2nd harmonic is enhanced on the foot arteries (Wang *et al.*, 1989b) and that means the 2nd harmonic can be the natural frequency of the main arteries of foot. The decrease in P2 during needling the foot acupoints supports this suggestion. This suggests that the 2nd harmonic is important not for

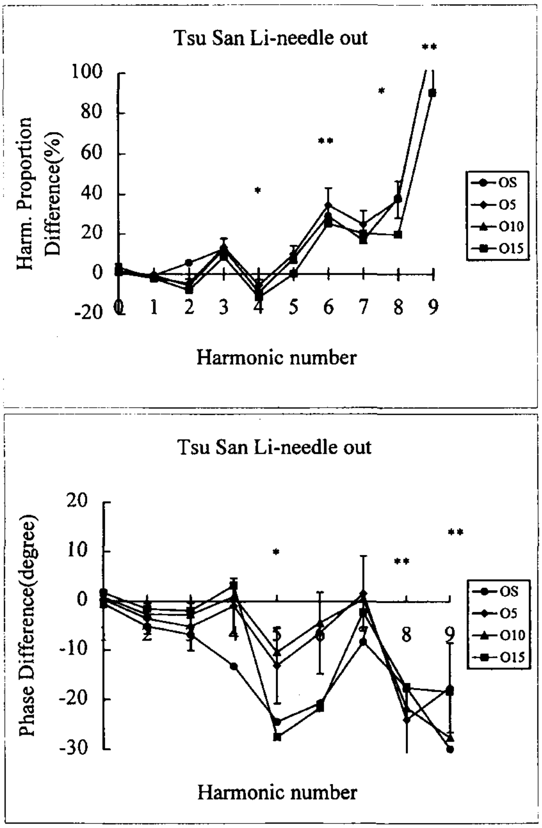

Figure 3: The acupuncture effect of Tsu-San-Li (from *Am. J. Chin. Med.* XXIII(2), pp. 121–130, 1995). Needle out periods are presented. The top set is the percent difference of the harmonic proportion; the bottom set is the difference of the phase angle. The means ± SEM (the standard error of mean) of the second curve (period O5) was plotted as the vertical bars and the T-test results between acupuncture Tsu-San-Li and the nonacupuncture groups for these two times are shown as * : P<(0.1), ** : P<(0.05), *** : P<(0.0 1).

the kidney (organ and meridian) only but also for all blood circulation to the lower limb. The inference is coincident with the general description of kidney function in Chinese medicine in which the kidney usually involved in every kind of lower body function. The fifth harmonic comes from the natural frequency of the coupled acupoints; this is the same for all the acupoints on the stomach meridian as well as stomach itself

(1b) The energy redistribution after acupuncture has a similar pattern for Hsien-Ku and Tsu-San-Li. The harmonic proportion of the 2nd harmonic (C2) is decreased. C3, C5, C6, C7, C8 and C9 are all increased. C3, C6 and C9 are the relative peaks to their neighboring harmonics and C2, C4 are the relative minimums. The therapeutic effects of acupuncture on Tsu-San-Li and Hsien-Ku are multifunctional and are not on the stomach only; therefore, an effect on harmonics other than C5 is reasonable. The energy redistribution patterns are coin-

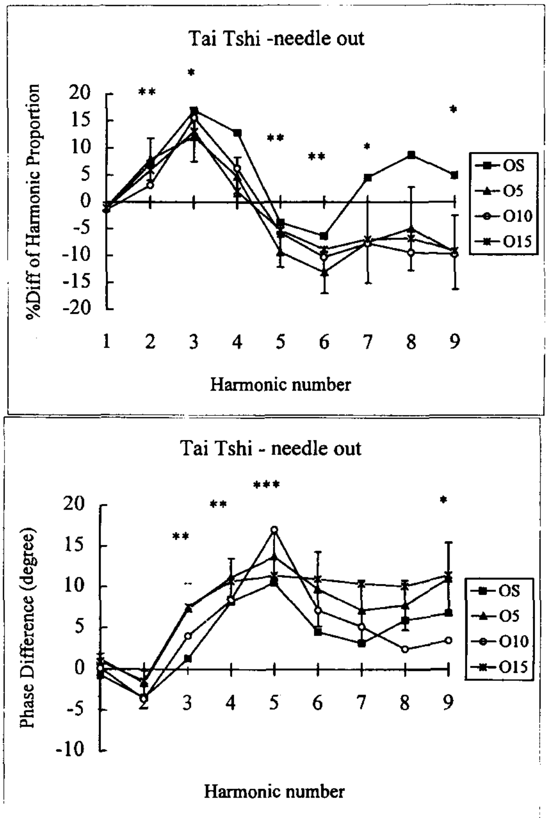

Figure 4: The acupuncture effect of Tai-Shih (from *Am. J. Chin. Med.* XXIII(3–4), pp. 305–313, 1996). Needle out periods are presented. The top set is the percent difference of the harmonic proportion; the bottom set is the difference of the phase angle. The means ± SEM (the standard error of mean) of the 2nd curve (period O5) was plotted as the vertical bars and the T-test results between acupuncture Tai-Shih group and the non-acupuncture group for these two times are shown as * : P<(0.1), ** : P<(0.05), *** : P<(0.0 1).

cident with their therapeutic effects. For example, acupuncture at Tsu-San-Li may strengthen the immune system (O'Connor and Bensky, 1975), or, as described in Chinese medicine, strengthen the "Chi." The increases of C3, C6, C9 may be responsible for these effects. This inference comes from other work we have done such as the study of the "chi" and immune function of the herb Ganoderma lucidum (Wang *et al.*, 1994a). The increasing C6 (gall bladder, enhanced harmonic on the head) may be responsible for beneficial effects on headache, C8 (large intestine) for relief of constipation and so on. Acupuncture Hsien-Ku may soothe facial edema (C5), colic of the intestine (C8), oscitation (C8), night sweat (C6) and so on; all these effects are not C5 dependent only.

There are two explanations for why the amplitude variation of C5, the assumed resonance harmonic for the stomach meridian, is not larger than some of the other harmonics after needling points on the stomach meridian. First, the energy redistribution is a whole body

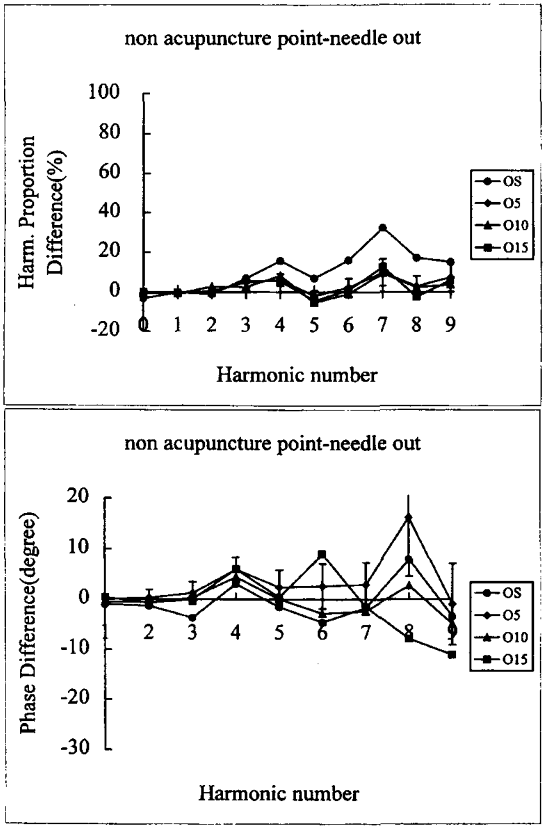

Figure 5: The acupuncture effect of non-acupuncture point (from *Am. J. Chin. Med.* XXIII(2), pp. 121–130, 1995). Needle out periods are presented. The top set is the percent difference of the harmonic proportion; the bottom set is the difference of the phase angle. The means ± SEM (the standard error of mean) of the 2nd curve (period O5) was plotted as the vertical bars.

process, it is not as sensitive to the resonance frequency in the wave propagation equation as the phase is. Second, since different harmonics have different amplitudes (harmonic proportions) in the pressure pulse spectrum, and the percentage harmonic proportion difference [%Diff.-Cn(Ti)]=100×[Cn(Ti)-Cn(T0)]/Cn(T0) is a ratio to the control amplitude Cn(T0), therefore the peak harmonic will not necessarily be at the resonance frequency. Usually, a lower harmonic has a larger harmonic proportion Cn(T0); in consequence, for the same percentage harmonic proportion difference, the lower harmonic will have the larger harmonic proportion difference [Cn(Ti)-Cn(T0)] and will be more important than the higher one. [Cn(Ti)-Cn(T0)] is not necessarily the largest at the resonance frequency either, since the value is strongly biased by the heart output.

(1c) The slight differences in the statistical significance of the effects may provide some detailed information for these two acupoints, which may come from their slightly different positions.

(2) From the results, different acupuncture effects for acupoints on different meridian are clearly shown. The effect of Tai-Tsih on the kidney meridian is different from the effects of Tsu-San-Li and Hsien-Ku on the stomach meridian.

(2a) The second harmonic (P2) is the only harmonic that does not increase significantly in phase difference for all three acupuncture points. This would be expected since the second harmonic is the natural frequency of the main arteries of the foot as we stated above. This is also consistent with the relationship between the kidney and the second harmonic.

(2b) Needling Tai-Tsih increased C2 and C3, with C3 as the peak, and decreased C5, C6, C7, C8 and C9 (Wang *et al.*, 1996a). The energy of the pressure wave is redistributed differently as compared with Tsu-San-Li and Hsien-Ku. This provides the possibility for treatment of different symptoms by different meridians.

Needling Tai-Tsih gave effects similar to kidney meridian related herbs (Wang *et al.*, 1998).

In this report, the frequency nature of acupuncture is clearly shown. Similar spectrum variation patterns will be produced if acupoints on the same meridian are needled, but there will be completely different patterns if the acupoints on different meridians are needled. These effects are significantly different from those obtained by needling a non-acupoint. This provides strong evidence that the frequency property of arterial blood pressure pulse is indeed meridian specific and therapy oriented. The needling effects may reflect autonomic reflexes in some other aspects such as analgesia resulting from neuro-endocrine changes. However, these effects are non-meridian specific. In contrast, needling influences the pressure spectrum of the circulatory system, its frequency property, in a meridian specific fashion that is therapeutically appropriate. To cause this specificity, there must be a meridian specific physical mechanism. The "resonance" theory may be the answer. Since these frequency effects may be linearly combined, one may then easily manipulate the acupuncture effect by combining different acupoints on different meridians to give a more specific treatment. In our previous reports, we found that Chinese herbal medicines, which are also meridian related, have a similar working mechanism (Wang *et al.,* 1994a,b, 1995b, 1997; Wang Lin *et al.,* 1992).

Much evidence indicates that Chinese medicine has a frequency structure. From the basic concept of the internal organ, the organ related meridian, and the "Chi", ... to clinical therapy, meridian related herbal medicine, acupuncture, and "Chi Kung," they can all be understood systematically by following the resonance and the frequency rule.

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