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Effect of Acupuncture at Tai-Tsih (K-3) on the Pulse Spectrum

Wei Kung Wang[1,4], Tse Lin Hsu[1], Hsi Chan Chang[2]
and Yuh Yin Lin Wang[3,4]

[1]*Biophysics Laboratory, Institute of Physics, Academia Sinica, Nankang, Taipei, Taiwan, 11529*
[2]*Traditional Chinese Medical School, Taichung*
3Department of Physics, National Taiwan Normal University, Taipei
[4]*National Research Institute of Chinese Medicine, Taipei, Taiwan*

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Abstract: The frequency specific acupuncture effect on Tai-Tsih (K-3) was examined by investigating pulse variations at the radial artery. The harmonic proportions of the 2nd, 3rd and the 4th harmonics were increased but the 5th, 6th and 9th harmonics were decreased significantly. The phase angles of all except the 2nd harmonic were increased (wave propagated slower). These results are compared with the frequency specific acupuncture effect on Tsu-San-Li (St-36) which we reported previously (Wang *et al.,* 1995a). This study solidified the weak coupling resonance theory, which successfully explains these frequency specific effects as well as the acupuncture mechanism.

Acupuncture is an important and effective therapeutic method in traditional Chinese medicine. In the past decades, scientific studies of acupuncture on different areas flourished. Acupuncture has been reported to be effective on analgesia (Bing *et al.,* 1990; Molsberger and Hille, 1994), anorexia (Shiraishi *et al.,* 1995; Liu, 1993), and blood pressure control (Ohsawa *et al.,* 1995; Williams *et al.,* 1991; Tam and Yiu, 1975). It induces reflex responses of gastric motility (Sato *et al.,* 1993; Li *et al.,* 1992; Sodipo and Falaiye, 1979) and micturition contractions of the urinary bladder (Sato *et al.,* 1992). It also influences nervous system activities (Sugiyama *et al.,* 1995; Wang and Liu, 1989), and modulates the endocrine system (He, 1987; Han and Terenius, 1982). However, the physiological status of acupuncture in these studies were not all scientifically described. There is still not much understanding of the essence of the acupoint and meridian, as well as the mechanism of acupuncture.

From 1987, we developed the resonance theory (Wang *et al.,* 1987; 1989a,b, 1991), and tried to understand the mechanism of Chinese medicine based on it. We suggested that the Fourier components of the pulse are related to the resonant conditions of blood pressure

distributions to the organs as well as the tissues (acupoints). The physical conditions of internal organs or tissues will influence their resonant status and affect blood pressure distribution. By analyzing pulse spectrum variations in organ clamping (Wang *et al.*, 1989a; Young *et al.*, 1989,1992; Yu *et al.*, 1994) and herb feeding experiments (Wang *et al.*, 1994a,b, 1995b; Wang Lin *et al.*, 1992), we obtained information on the resonance frequencies of different organs. Internal organs were linked with different harmonics of the pressure pulse: liver is related to the 1st harmonic, kidney: the 2nd, spleen: the 3rd, lung: the 4th, stomach: the 5th, and so on.

Acupoint is supposed to be a weakly coupled arterial tree, which resonates in two specific frequencies. One is the nature frequency of the main artery. The other is its own nature frequency which is the same for all acupoints on the same meridian, and is the same as the resonant frequency of the meridian related organ. During weak coupling, the pressure spectrum of the main artery is not affected. Blood pressure distribution on the meridian and its related organ will both be varied if the resonance status of either one is disturbed. Therefore, study of the acupuncture effect on the pressure spectrum may help to understand the frequency characteristic of an acupoint as well as its mechanism.

Previously, we had investigated the acupuncture effect on Tsu-San-Li (St-36) (Wang *et at.*, 1995a). We inferred the resonant frequency of the stomach meridian (the 5th harmonic) from frequency specific phase angle changing. Our inference is consistent with clinical observation. In this study, we examined another acupoint, Tai-Tsih (K-3), on the kidney meridian to re-affirm the weak coupling theory.

Material and Method

1. Subjects

25 healthy subjects, 13 males, 12 females, aged between 20 to 55 were tested. All subjects were asked not to take any medication 3 days before 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

Experimental setup was similar as described in our previous report (Wang *et al.*, 1995a). Briefly, each subject was asked to sit down. The right 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. Our criterion of a good measurement was to seek the largest amplitude of the pulse. Six consecutive pressure pulses were taken as control. An acupuncture needle was then inserted into Tai-Tsih (K-3), which was located in the fossa between the medial malleolus and the achilles tendon. No special acupuncture treatment (manipulating the needles to increase or decrease "Chi") was done in this period. Pressure pulses were then taken at 10 sec, 5 min, 10 min and 15 min before and after needling. The pressure transducer

was not removed during the entire measuring process.

Control P(T0) ➡ insert needle ➡ 10 seconds P(TNs)➡ 5 min P(TNs)
➡ 10 min P(TN10)➡15 min P(TN15)
⬇
take out needle ➡ 10 seconds P(TOs)➡ 5 min P(TOs)
➡ 10 min P(TO10) ➡15 min P(TO15)

3. Data analysis

Output of the transducer was connected to an IBM PC via an A/D converter with sampling rate of 430 data points/sec. Pulse spectrum was analyzed with Fourier transform using T (period) = 1 pulse.

Standard deviation of heart rate from 6 pulses in a measurement was not allowed to exceed 5%. Every pulse spectrum measurement at needle in and needle out periods was compared with the pulse spectrum measured at the control period. To keep the Fourier transform meaningful, we excluded measurements with heart rate difference exceeding 10% of control. Variations of pulse spectra between these comparisons were expressed as the percent difference of the harmonic proportions and the phase difference from harmonics 1 to 9.

Percent difference of the harmonic proportions of harmonic n between
period Ti and control = %Diff. – Cn(Ti) = [Cn(Ti) – Cn(TO)]/Cn(TO)

where Cn(TO) = (An/AO) at control period
= harmonic proportion of the nth harmonic at control period
Cn(Ti) = (An/AO) at period i
= harmonic proportion of the nth harmonic at period i
An : amplitude of the nth harmonic
AO : DC value of the pulse spectrum
Ti : Period i
TO : control period

Phase difference of the nth harmonic [Diff. – Pn(Ti)] = Pn(Ti) – Pn(TO)

where Pn : phase angle of the nth harmonic

4. Statistics

The Diff. - Pn(Ti) and %Diff. - Cn(Ti) of all subjects were averaged. Student's t-tests were performed to decide the significance level between the means and zero.

Results

Percent difference of the harmonic proportions (%Diff.-Cn(Ti)) of the average acupuncture

effects on Tai Tshi is shown in Figure 1. Standard errors of mean and t-test results of N5 (needle-in 5 minutes) and O5 (needle-out 5 minutes) periods were also presented. Standard errors of mean were similar for all other periods. Significant level between the mean of (%Diff. - Cn(Ti)) and zero for all periods are shown in the t-test results on Table 1. It is noted that the energy of the pressure wave was redistributed after acupuncture at Tai-Tshi. Harmonic proportions of the 2nd, 3rd and 4th harmonics were increased but all the higher harmonics were decreased. The significant level were especially high on the 3rd, 4th, 5th, 6th and 9th harmonics at most of the experimental periods.

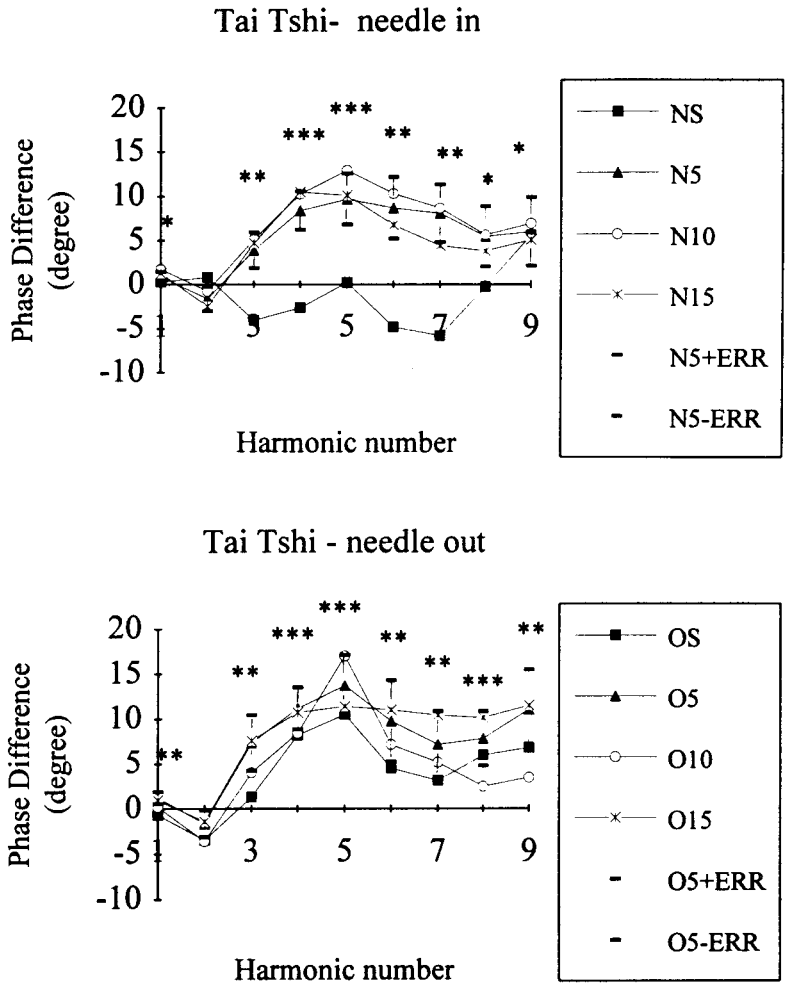

Figure 1. Effect of difference of harmonic proportions of acupuncture at Tai Tshi. The means ± SEM (the standard error of mean) of the second curve (period of NS of the top set, 05 of the bottom set) were also plotted as NS + ERR, NS - ERR, OS + ERR and OS - ERR respectively. T-test results of the NS, 05 periods are shown as *: $P < (0.1)$, **: $P < (0.05)$ and ***: $P < (0.01)$.

Table 1. The T-test result of the %difference of harmonic proportions between zero and the mean of acupuncture effect at Tai-Tshi

	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).

Standard errors of mean and t-test results of NS (needle-in 5 minutes) and O5 (needle-out 5 minutes) periods are presented in Table 2.

Table 2. The T-test result of the phase angle difference between zero and the mean of acupuncture effect at Tai-Tshi

	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 average effects of phase difference (Diff. - Pn(Ti)) are shown in figure 2. Phase angle of the 2nd harmonic was decreased (wave propagated faster) but all other harmonics were significantly increased. Significant decrease of phase angle of the 2nd harmonic was noted only on the O5, O10 periods, while significant increase for all other harmonics was shown at almost all periods.

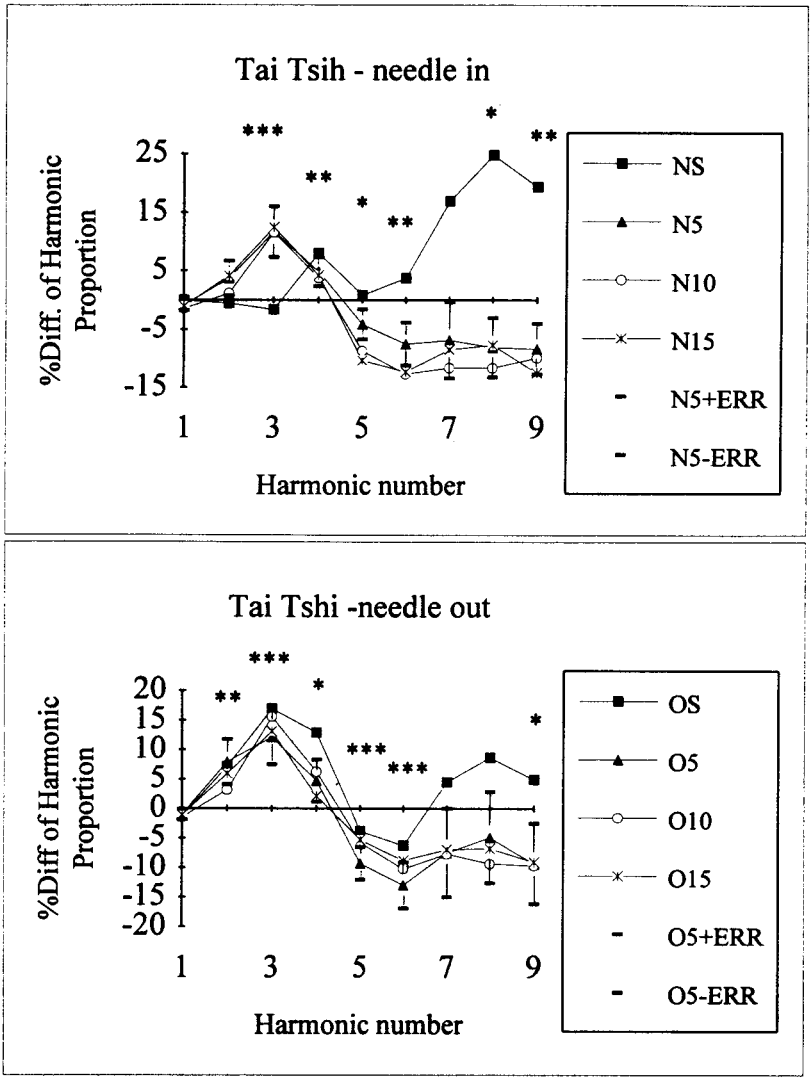

Figure 2. Effect of difference of phase angle of acupuncture at Tai-Tshi. The means ± SEM (the standard error of mean) of the second curve (period of NS of the top set, O5 of the bottom set) were also plotted as NS + ERR, NS - ERR, OS + ERR and OS - ERR respectively. T-test results of the NS, O5 periods are shown as *: $P < (0.1)$, **: $P < (0.05)$ and ***: $P < (0.01)$.

Discussion

Based on the resonance theory, we have derived wave propagation equations, which describe amplitude and phase properties of the blood pressure wave in a resonant coupling system. According to these equations, phase change is very sensitive to resonance frequency (Wang and Wang Lin, 1992, Wang *et al.,* 1992, 1994b). Thus we may infer the resonance frequency of tissue by observing phase variation of the pressure spectrum under physical disturbance. Acupuncture may stiffen the tissue and, as a result, the pressure wave will travel faster as seen by a smaller phase angle at the resonance frequency.

In our previous studies on Tsu-San-Li (Wang *et al.,* 1995a), needling the acupoint decreased phase angle of the 5th harmonic wave. This harmonic was, therefore, suggested to be the resonance frequency of Tsu-San-Li, which is on the stomach meridian. We noticed that the resonant frequency for the stomach meridian and its related organ stomach is the same, the 5th harmonic.

Acupuncture effect on Tai-Tshi in this study indicated that phase angle at the 2nd harmonic wave was decreased. The 2nd harmonic is, therefore, suggested to be the resonance frequency of Tai-Tshi as well as the kidney meridian. Again, we noticed that the resonant frequency for kidney meridian and its related organ (kidney) is the same. Phase angles for all other harmonics, except the 2nd harmonic, increased significantly in this study. Acupuncture at Tai-Tshi causes these harmonic waves to propagate slower, and the 2nd harmonic wave relatively faster. We did not find this kind of effect in the Tsu-San-Li study.

In the Tai-Tshi study, blood pressure energy of the 2nd, 3rd and 4th harmonics was increased but all other (higher) harmonics were decreased. According to Chinese acupuncture literature, symptoms such as Infantile eclampsia, otalgia, nephralgia, beriberi, endocarditis, asthma, and vomiting could be relieved by acupuncture at Tai-Tshi alone or in combination with other acupoints. The related organs or meridians to these symptoms are in coincidence with the varied harmonics mentioned above. We have suggested that the therapeutic effect of acupuncture or herb treatment may be due to their abilities to redistribute blood supply to different part of the body (Wang *et al.,* 1994a, b). This may improve health status by providing more nutrition and oxygen to and taking away more waste from a needed location, which we may assign in a frequency specific way. Both data from the Tai-Tshi and Tsu-San-Li studies support this concept.

So far, evidence from the investigation of acupoints Tsu-San-Li and Tai-Tshi strongly support the weak coupling resonance theory. Based on this theory, we determined the resonance frequencies for these acupoints from phase variations. We found that these acupoints and their related organs have the same resonance frequencies as suggested by the theory. The therapeutic effect of acupuncture is in coincidence with its effect on amplitude of the pressure pulse spectrum.

In conclusion, the scientific nature of acupoints and meridians is well described in the weak coupling theory. Acupuncture mechanism is a frequency depending process, which is decided by how the resonance status between acupoint and its weak coupled main artery is disturbed. The resonance theory is once again confirmed as a fundamental principle in Chinese medicine. Pulse diagnosis, herb treatment, acupuncture or Qigong are all based on the frequency characteristics described above.

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