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RESEARCH ARTICLE

Magneto-Acupuncture Stimuli Effects on Ultraweak Photon Emission from Hands of Healthy Persons

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Abstract
We investigated ultraweak photon emissions from the hands of 45 healthy persons before and after magneto-acupuncture stimuli. Photon emissions were measured by using two photomultiplier tubes in the spectral range of UV and visible. Several statistical quantities such as the average intensity, the standard deviation, the δ-value, and the degree of asymmetry were calculated from the measurements of photon emissions before and after the magneto-acupuncture stimuli. The distributions of the quantities from the measurements with the magneto-acupuncture stimuli were more differentiable than those of the groups without any stimuli and with the sham magnets. We also analyzed the magneto-acupuncture stimuli effects on the photon emissions through a year-long measurement for two subjects. The individualities of the subjects increased the differences of photon emissions compared to the above group study before and after magnetic stimuli. The changes on the ultraweak photon emission rates of hand for the magnet group were detected conclusively in the quantities of the averages and standard deviations.

1. Introduction

Static magnetic fields may have significant clinical utility while pulsed magnetic fields show more potent effects on biological systems [1,2]. Because much research has focused on pulsed fields, fewer investigations have been made on static or permanent field effects. Evidence was gathered that showed a significant effect of static magnetic fields with high magnetic flux densities, for example, on the cardiovascular system [3–5]. A few studies also provided evidence of a possible therapeutic role for permanent magnets in pain reduction [6–9].

Recently magnetic field stimulation on acupuncture points has been getting more attention because of its non-invasive nature. Magneto-acupuncture is in contrast to the usual manual acupuncture or electro-acupuncture that uses the direct insertion of a metal needle into skin or a supply of electric current. Although the fundamentals of acupuncture treatment remain poorly understood [10], considerable investigations have been made to elucidate the structure and mechanism underlying the meridian system in the various aspects [11–13]. Electro-acupuncture may be viewed as a modern extension of acupuncture, which was brought about by the introduction of the electronics into acupuncture [14,15]. Biological effects of electro-acupuncture [16–18] have been well studied compared with those of magneto-acupuncture.

In general, however, it has been difficult and controversial to define a biological response to static

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magnetic fields in animal experiments as well as in human studies. This difficulty may be partly attributed to the absence of an apparatus sensitive enough to detect significant changes among very weak biological signals. It was known that all biological systems continuously emit photons with very weak intensity of about 10^{-16} Watt/cm^2 in the spectral range from ultraviolet to near infrared without any external stimulation. This phenomenon was referred to as 'biophoton' emission [19,20] differing from the usual bioluminescence [21]. These ultraweak photon emissions of various biological systems from mammalian cells to human bodies were detected by very sensitive photo-detecting systems using photomultiplier tubes [22]. Previous results have revealed some associations between the biophoton emissions and the physiological states of living systems, including the oxidative metabolism, germination of seedlings, embryology, morphogenesis, oncology, injury and healing [23–29].

In our previous works we have measured the biophoton emissions from human hands for a long period of time [30,31]. We tried to establish the relationship between the biophoton measurements and the functional balance of the left and right parts of a human body in the light of the diagnostic view of traditional oriental medicine. In this paper we analyzed the magneto-acupuncture stimuli effects on the ultraweak biophoton emission of human hands. Because the focus of this investigation was not on the therapeutic effects of the magneto-acupuncture treatment, the subjects of experiments were all healthy volunteers.

2. Materials and Methods

2.1. Design of photo-detection system

All experiments were done in a light-tight environment due to the extremely low intensity of light emission from human hands. The dark room during the measurements was kept at a temperature of $20\pm2^{\circ}$C and a humidity of $40\pm10\%$. Equipment was assembled to count the number of photons emitted from the left and right human hands simultaneously as shown in Figure 1. The experimental setup consisted of two photomultiplier tubes (PMTs) and associated electronic devices. Two head-on type PMTs (R331-05S, Hamamatsu Photonics, Japan) were installed and mounted inside the dark chamber with a size of 330 mm × 600 mm × 420 mm on a desk. The dark chamber was separated by a plate in the middle so that the left and right hand of a subject sitting in a chair were put on the PMTs in each side of the compartment. The minimum useful area of the PMT for the photon detection was 46 mm in diameter and

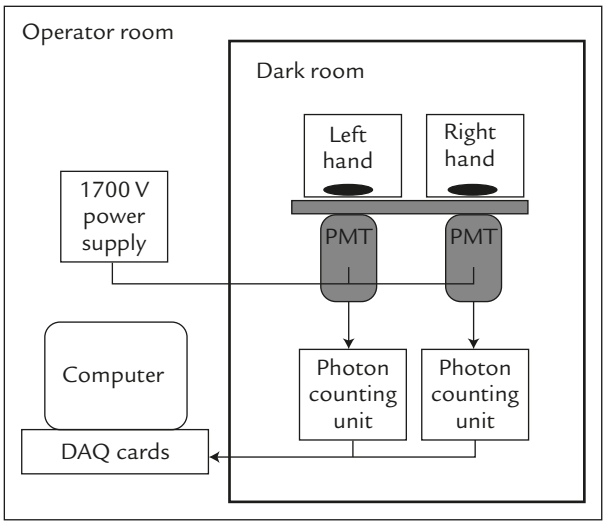

Figure 1 Schematic diagram of the experimental setup for measurements of photon emission from human hands. The dark room is inside the operator room.

the spectral response was from UV to visible light (300 nm–650 nm). Each PMT was enclosed by a magnetic shielding and housing case. The distance between the front surface of the photo-cathode of the PMTs and the positioning of the hands was about 20 mm. The photon-counting units (C6465) amplified and discriminated electric current signals from the PMTs and converted them to countable square pulses. The photon counting boards (M8784) inside the desktop computer were synchronized with their gate time of 100 ms for simultaneous counting. The dark room in Figure 1 was a completely dark area so the background signals with no subject were almost the same as the dark counts of two PMTs: the dark counts of two PMTs for the left and right hand side were 13 ± 4 counts per second (cps) and 15 ± 5 cps, respectively.

2.2. Experimental procedure

The experiment was designed to measure photon emissions from the dorsum and palm of the left and right hands. All subjects stayed in the operator room (Figure 1) before starting measurements for at least 1 hour under a dim red light in order to eliminate any effect of sunlight exposure. During that time the subject removed all metallic belongings from their body and cleaned their hands with ethanol-soaked cotton. After the subject entered the dark room, the measurements were made in the following steps: a 10-minute initial adjustment sitting in a chair, measuring the photon emission from the dorsal part of the hands (back) for 3 minutes and, without any delay, measuring photon emission from the palms of the hands for 3 minutes. After exiting from the dark room, the subject had magneto-acupuncture stimuli by a meridian therapist for an hour. Then, the

photon emission rates were measured again following the same procedure as before the treatment.

2.3. Subjects and magnetic stimuli on acupuncture points

Total 45 healthy persons (29 men and 16 women) in the age range of 18–50 years participated in the experiment. Eight subjects were for a control (Group I), 4 subjects were treated with sham magnets (Group II), and 33 subjects received treatment with magnets (Group III). Groups I, II, and III were composed of six men and two women, three men and one woman, and 20 men and 13 women. We call Groups I, II, and III as the non-magnet control, sham group, and magnet group, respectively. The same procedure for the Group I was followed with the control session as with the treatment session except for the magneto-acupuncture stimuli. Group I just relaxed in the operator's room during the intermission. The experimental procedure for Group II was the same as that for Group III, but the magnets were replaced by the sham magnets without any magnetic field. As for Group III, after finishing the first measurements of photon emission, they were treated with 14 magnets whose intensity was about 2000 gauss. The shape of the magnet was circular with 7 mm diameter and thin with 2 mm thickness. Fourteen magnets were attached on hands and feet along to the acupuncture map (Figure 2) for 1 hour. After a brief examination of the subject's constitution by a magneto-acupuncturist, stimulated acupoints were chosen among the 17 acupoints distributed over each hand or foot, respectively, as shown in Figure 2. The stimulated points were also different for every person. The north-poles of seven magnets and the south-poles of the remaining seven magnets were directed to face the surface of the skin. Photon emission rates were measured again following the same procedure as in the first measurement. Especially, two persons in Group III attended for year-long measurements from November 2003 to November 2004 every Tuesday. In this case, the stimulated acupoints for these two persons were kept the same during the whole measurement period. All the participants gave informed consents to the scientific research.

2.4. Time-series data analysis for photon emission

The measured signals through the PMTs contained rapidly changing random fluctuations and were more or less stationary over the long measuring-time interval. In this situation the moments of the signals capture useful quantitative properties [32]. We calculated the two moments most used for quantification of the signals. The first-order moment is the average or mean value of the signals. It indicates the averaged intensity of photon emission. The second one is the central moment of order 2, which is the variance. For the presentation of the data, we used the square root of the variance, the standard deviation (SD). The variance and the SD indicate the spread of magnitudes of a signal. Another quantity that we calculated was the δ-value of signals. This value is a combination of the average and variance as follows:

$$\delta \equiv (\mathrm{SD}^2 - \mathrm{average})/\mathrm{average}$$

This quantity indicates a measure of agreement with the Poissonian distribution of photon emission rate and is used as an index for the degree of coherence of the signals [33]. Lastly, in order to present the left-right difference in the photon emissions we also calculated the quantity for an asymmetry as follows:

$$\mathrm{ASYM} \equiv (\mathrm{average}_{\mathrm{Left}} - \mathrm{average}_{\mathrm{Right}})/(\mathrm{average}_{\mathrm{Left}} - \mathrm{average}_{\mathrm{Right}})$$

This quantity represents the degree of unbalance between the averaged intensities of photon emissions from left and right hands.

2.5. Statistical analysis

The statistical quantities from the two groups were presented as mean$\pm$SEM (standard error of the mean). Every quantity was tested for deviations from the Gaussian distribution using the Kolmogorov-Smirnov test. For comparison between two groups, unpaired *t*-test and non-parametric test (the Mann-Whitney test) were employed. In the same group, for a comparison between photon emission data before and after the treatment, a paired test (the Wilcoxon-signed rank test) was made. In all statistical tests, the level of $p \leq 0.05$ was considered as significant.

3. Results

3.1. Overall data analysis

In Table 1, we present all the statistical quantities for the non-magnet control group (Group I): the average, SD, and the δ-value for the left and right of the backs and palms of hands as well as the left-right asymmetry (ASYM). The normality tests for all the quantities were passed. All these quantities before and after the control sessions were also compared by non-parametric paired tests. The corresponding *p* values for the quantities were calculated in the last column of the table. No significant differences were observed between the medians before and after for the control data except for just one case: the

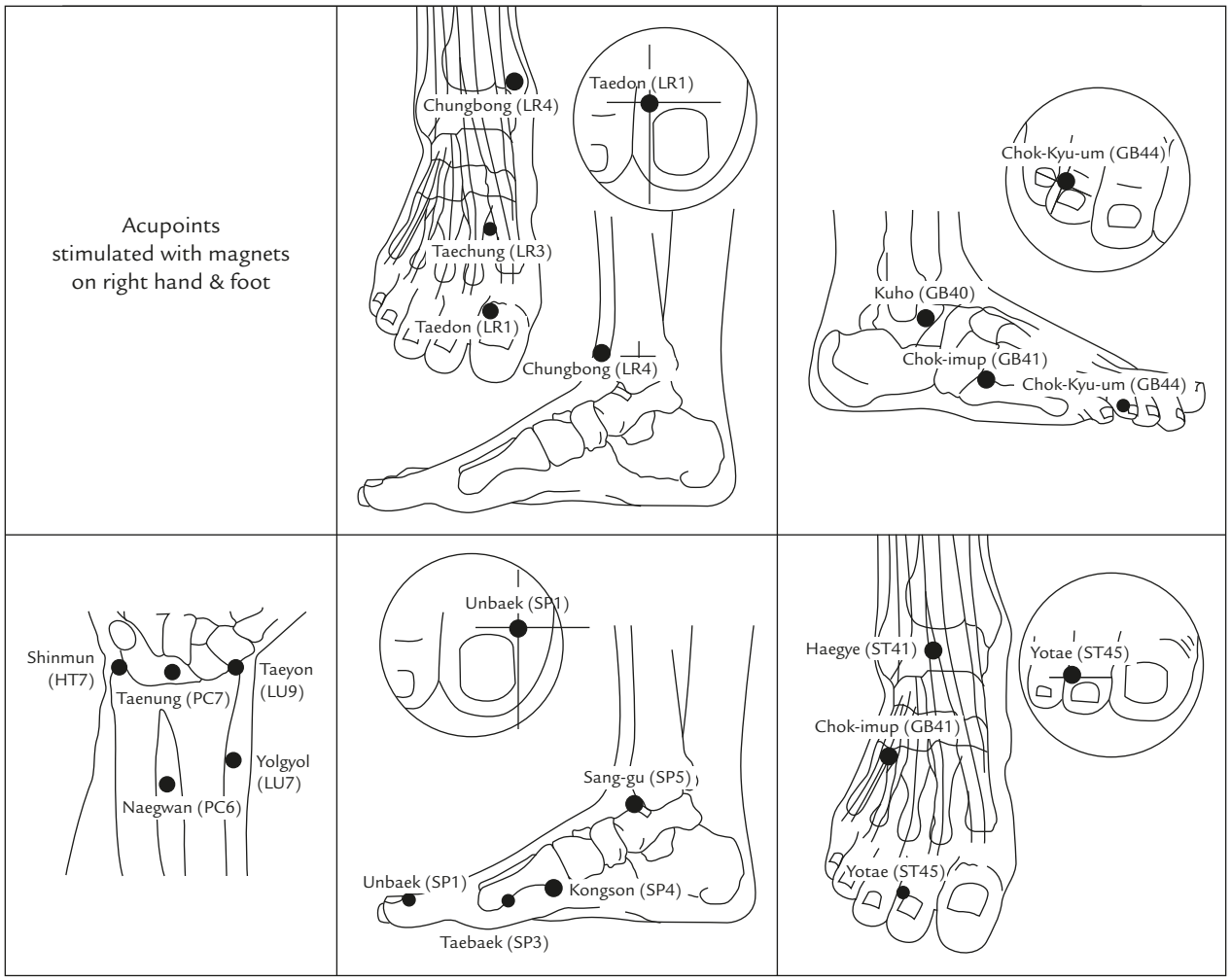

Figure 2A Acupuncture points for the magnet stimuli: It shows total 34 points which were composed of 17 points in the right hand & foot. Fourteen magnets were attached among them.

average of the right palm (p=0.04). In the case of the sham group (Group II), there were no significant differences before and after stimuli by the sham magnets as shown in the Table 2. In the case of the magnet group (Group III), there were several instances of quantities which failed to pass the normality test as shown by the superscripts in the second and third columns in Table 3. Significant differences in the average and SD of photon emission from the left and right palm were shown by the magneto-acupuncture stimuli. The unpaired tests between the quantities from the non-magnet group and the magnet group showed significant difference only for the SD of photon emission rate from the back of left hands after the treatment (p=0.04). In Figure 3, we plotted the differences in the averages of photon intensity between before and after the treatments for the three groups. The photon emissions before the treatment were subtracted from the photon emissions after the treatment. In the control group, the average photon emission intensities from the back and palm of both hands were reduced by around 25 cps. For the magnet group, the reductions in the average photon emission intensities from the back of both hands were reduced to 10 cps. In case of the sham test group, the average photon emission, the SD and δ-value were not changed significantly before and after magnet stimuli. The positive values in the average difference of photon emissions did not mean that all the subjects emitted a smaller number of photons after the treatment. Two among eight subjects for the control group emitted more photons from both hands after the control session. In the case of the magnet group, nine subjects from the back and five subjects from the palm had larger intensities of photon emissions from both hands after the treatment session.

3.2. Individual data analysis

Two subjects participated in the experiments for a year and measured photon emissions every Tuesday. The numbers of experiments for subjects 1 and 2 were 37 and 38, respectively. They were treated with the magneto-acupuncture stimuli at the same points

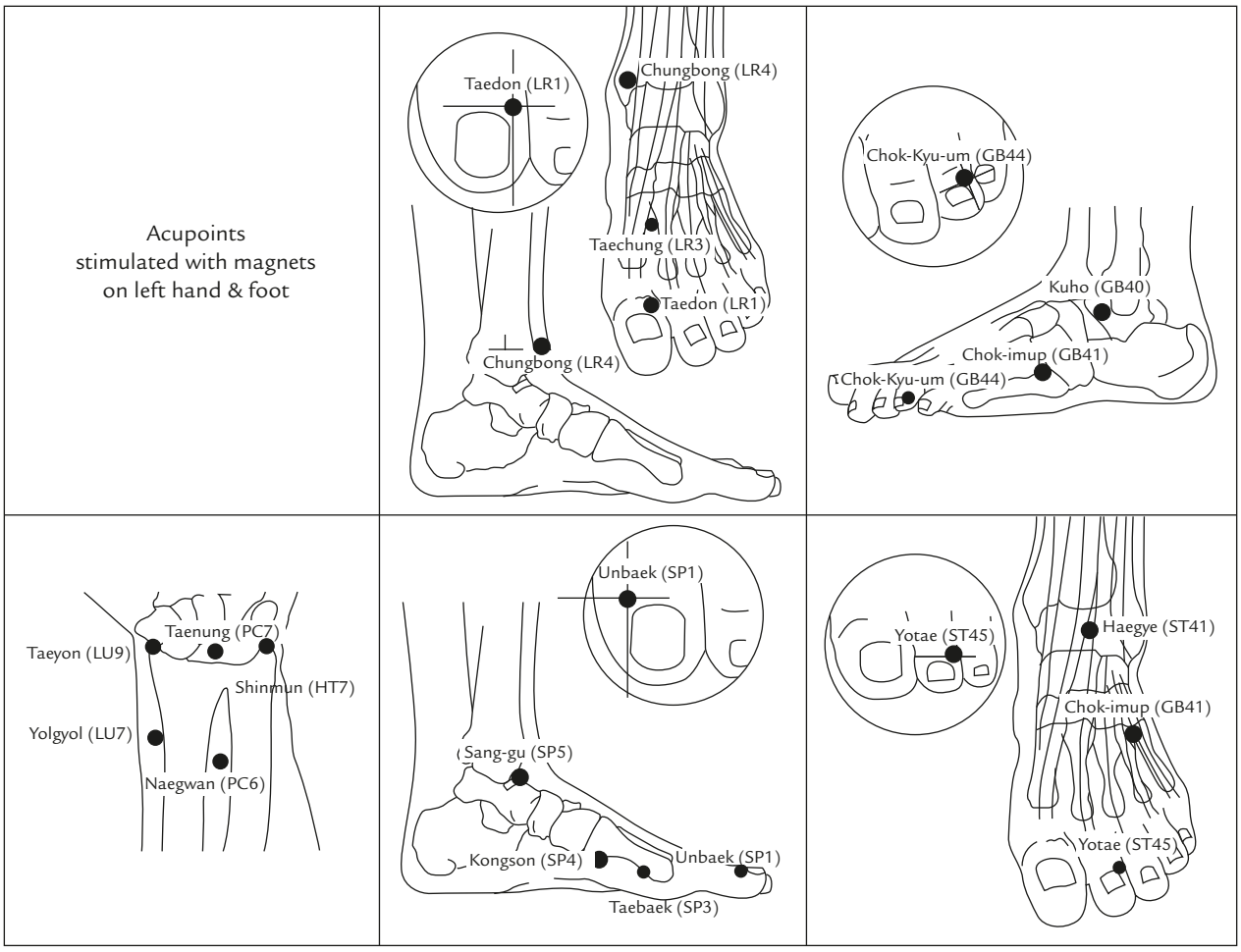

Figure 2B Acupuncture points for the magnet stimuli: It shows total 34 points which were composed of 17 points in the left hand & foot. Fourteen magnets were attached among them.

Table 1 Statistical quantities for the control group

Group I (n=8)		Before (mean±SEM)	After (mean±SEM)	Paired test p value
Hand	Quantities			
Back				
Left	Average (cps)	181±26	157±17	0.08 (ns)
	SD (cps)	17.9±2.4	17.5±2.2	0.78 (ns)
	δ	0.86±0.27	1.02±0.34	0.60 (ns)
Right	Average (cps)	178±25	150±18	0.08 (ns)
	SD (cps)	17.0±1.8	16.2±2.5	0.25 (ns)
	δ	0.67±0.18	0.79±0.36	0.19 (ns)
	ASYM ($\times 10^3$)	2±31	28±34	0.31 (ns)
Palm				
Left	Average (cps)	145±16	122±11	0.08 (ns)
	SD (cps)	12.9±0.8	11.9±0.4	0.19 (ns)
	δ	0.18±0.07	0.20±0.05	0.64 (ns)
Right	Average (cps)	159±23	132±13	0.04 (*)
	SD (cps)	13.3±0.9	12.1±0.6	0.31 (ns)
	δ	0.16±0.09	0.14±0.04	0.84 (ns)
	ASYM ($\times 10^3$)	−39±19	−41±16	0.88 (ns)

*Statistically significant differences from the paired test.

Table 2 Statistical quantities for the sham group

Group II ($n=4$)		Before (mean±SEM)	After (mean±SEM)	Paired test p value
Hand	Quantities			
Back				
Left	Average (cps)	112±24	104±18	0.09 (ns)
	SD (cps)	12.4±2.7	14.0±4.8	0.20 (ns)
	δ	0.38±0.37	0.98±1.12	0.09 (ns)
Right	Average (cps)	136±37	133±39	0.81 (ns)
	SD (cps)	13.5±3.0	16.3±8.7	0.23 (ns)
	δ	0.36±0.39	1.18±2.02	0.17 (ns)
	ASYM ($\times 10^3$)	−93±99	−111±104	0.62 (ns)
Palm				
Left	Average (cps)	198±53	174±49	0.08 (ns)
	SD (cps)	16.8±4.0	15.6±3.9	0.40 (ns)
	δ	0.47±0.58	0.41±0.37	0.81 (ns)
Right	Average (cps)	215±46	197±61	0.31 (ns)
	SD (cps)	17.9±3.2	16.4±4.6	0.40 (ns)
	δ	0.54±0.56	0.37±0.38	0.51 (ns)
	ASYM ($\times 10^3$)	−46±66	−63±59	0.58 (ns)

Table 3 Statistical quantities for the magnet group

Group III ($n=33$)		Before (mean±SEM)	After (mean±SEM)	Paired test p value
Hand	Quantities			
Back				
Left	Average (cps)	135±11	123±13	0.06 (ns)
	SD (cps)	13.5±0.8	15.4±2.5*	0.84 (ns)
	δ	0.44±0.09	1.22±0.68*	0.17 (ns)
Right	Average (cps)	133±9	125±12*	0.08 (ns)
	SD (cps)	13.6±0.7	14.4±1.3	0.95 (ns)
	δ	0.46±0.10	0.75±0.21*	0.10 (ns)
	ASYM ($\times 10^3$)	−6±15	−19±16	0.39 (ns)
Palm				
Left	Average (cps)	156±9	130±6	<0.0001**
	SD (cps)	12.9±0.4	12.0±0.3	0.0002**
	δ	0.11±0.03	0.13±0.15	0.64 (ns)
Right	Average (cps)	172±13	137±7	<0.0001**
	SD (cps)	14.5±1.3*	12.2±0.3	<0.0001**
	δ	0.28±0.15*	0.11±0.02	0.40 (ns)
	ASYM ($\times 10^3$)	−33±19	−27±11	0.63 (ns)

*Statistically significant differences from the normality test. **Statistically significant differences from the paired test.

on both hands and feet for each measurement for a year. The statistical quantities for the subjects were calculated and presented in Tables 4 and 5. As in the previous tables (Tables 1–3), the superscripts in the second (before) and third (after) columns were the results of the normality tests. Several cases failed to pass the tests, especially in the case of the δ-value. In the fourth column, we presented the difference values of the quantities in the form of mean±SD and the results of the paired non-parametric tests in parenthesis. The difference values were obtained by subtracting the values after the treatment from the values before the treatment. As we can see through the tables, almost all the standard errors of the mean (SEM) values from the individual data were smaller than those of the combined overall

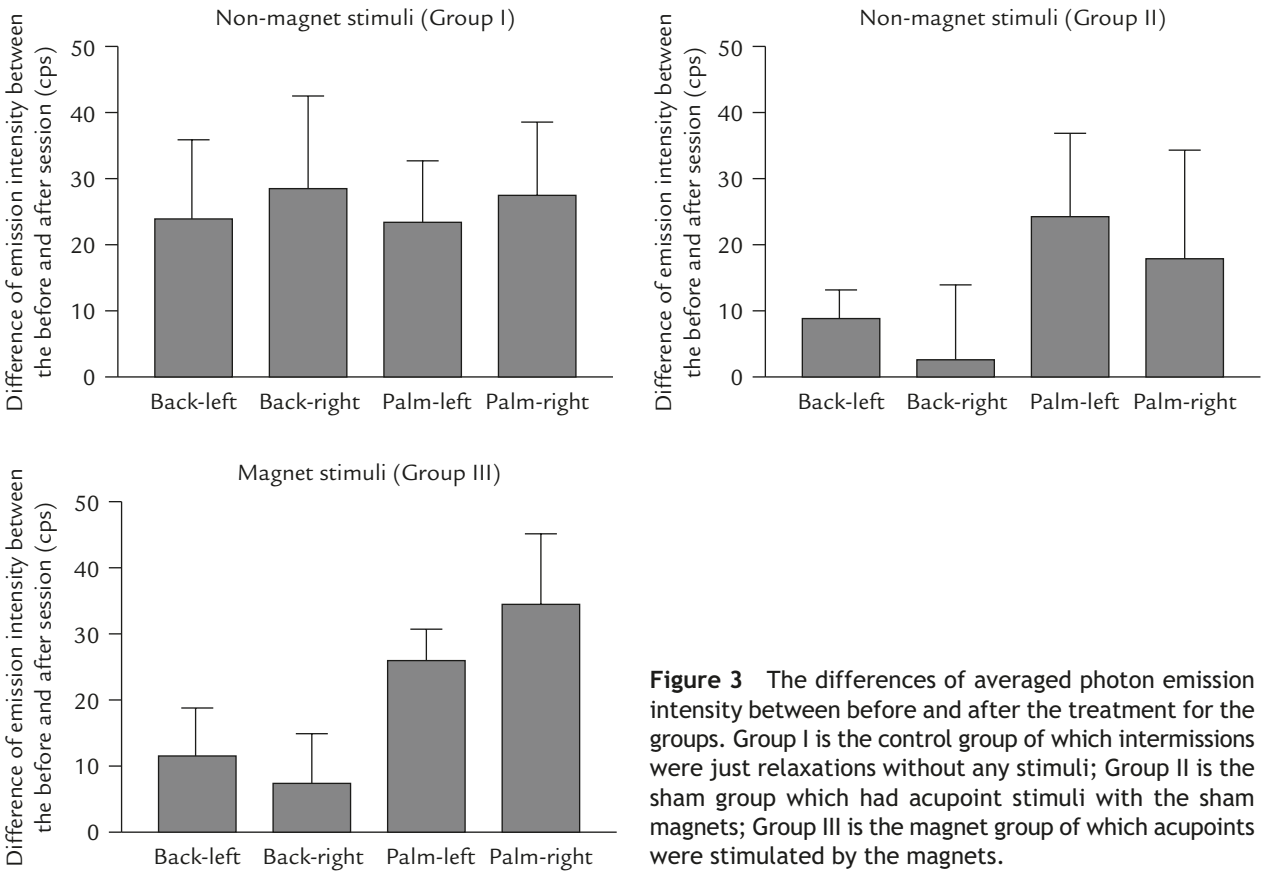

Figure 3 The differences of averaged photon emission intensity between before and after the treatment for the groups. Group I is the control group of which intermissions were just relaxations without any stimuli; Group II is the sham group which had acupoint stimuli with the sham magnets; Group III is the magnet group of which acupoints were stimulated by the magnets.

Table 4 Statistical quantities for subject 1: a year-long measurement

Subject 1 (n=37)		Before (mean±SEM)	After (mean±SEM)	Difference (mean±SEM)
Hand	Quantities			
Back				
Left	Average (cps)	116±5	89±4	27±3**
	SD (cps)	14.3±0.6	12.3±0.4	2.0±0.5**
	δ	0.8±0.1	0.7±0.1	0.06±0.11 (ns)
Right	Average (cps)	130±6	109±5	21±2**
	SD (cps)	15.1±0.8*	14.7±0.7	0.4±0.6 (ns)
	δ	0.8±0.2*	1.0±0.1	−0.2±0.2 (ns)
	ASYM ($\times 10^3$)	−59±15	−95±15	36±11**
Palm				
Left	Average (cps)	167±8	126±5	41±4**
	SD (cps)	14.2±0.5	11.8±0.3	2.4±0.3**
	δ	0.23±0.03	0.13±0.3	0.10±0.05**
Right	Average (cps)	155±6	123±5	32±3**
	SD (cps)	13.2±0.4	11.6±0.2	1.7±0.3**
	δ	0.14±0.03	0.10±0.02	0.04±0.04 (ns)
	ASYM ($\times 10^3$)	27±15	8±11	19±8**

*Statistically significant differences from the normality test. **Statistically significant differences from the paired test.

data. Significant differences were also found for more of the quantities from both the backs and the palms of hands than for those from the overall data analysis.

4. Discussion

The changes in the measured quantities from the non-magnetic groups by the control sessions and

Table 5 Statistical quantities for subject 2: a year-long measurement

Subject 2 ($n=38$)		Before (mean±SEM)	After (mean±SEM)	Difference (mean±SEM)
Hand	Quantities			
Back				
Left	Average (cps)	127±7	97±7	30±5**
	SD (cps)	14.4±0.7	12.4±0.7	2.0±0.6**
	δ	0.7±0.1	0.6±0.1	0.09±0.10 (ns)
Right	Average (cps)	122±5	91±4	30±3**
	SD (cps)	15.6±0.6	12.6±0.5	3.0±0.5**
	δ	1.1±0.1*	0.8±0.1	0.3±0.1**
	ASYM ($\times 10^3$)	11±14	15±15	−4±15 (ns)
Palm				
Left	Average (cps)	142±6	99±3	44±4**
	SD (cps)	13.2±0.5	10.7±0.2	2.5±053**
	δ	0.27±0.09*	0.18±0.02	0.10±0.05 (ns)
Right	Average (cps)	163±6	118±4	45±4**
	SD (cps)	13.7±0.4	11.8±0.4	1.8±0.5**
	δ	0.17±0.03	0.22±0.06	−0.05±0.07 (ns)
	ASYM ($\times 10^3$)	−72±8	−93±7	20±7**

*Statistically significant differences from the normality test. **Statistically significant differences from the paired test.

the sham test without any magnetic stimuli were not significant, while the changes for the magnet group were evident in the case of the averages and standard deviations for the photon emission rates of palm. For the magnet stimuli group, the differences in the intensities of photon emission rates from the dorsal parts of left and right hands appeared to be smaller than those of the palm parts. In other words, by the magneto-acupuncture stimuli, the changes in the averaged intensities of photon emissions from the dorsal parts were smaller than those from the palm parts. This means more photon emissions from the dorsal parts after the magneto-acupuncture stimuli than from those of the control group. The trend in the average intensities of photon emission before and after the stimuli was more clearly discernible through a comparison with the individual data. The average and the SD of photon emission data could be good discriminators for the magnetic stimuli while the δ-value and the asymmetry value were not, for the combined overall group. The δ-values for the palms of hands were much smaller than those for the back in every case. This implies more coherent photon emissions from palm and low coherency at the dorsa.

In our previous work [31], the active nature of dorsal hands and personal discernible patterns in palm were investigated through frequency count analysis of biophoton emission rates. The seasonal dependency of biophoton emission from human hands was measured and found to be lowest in autumn. The emission rates from the palms remained rather stable throughout the year while those from the dorsa vary widely depending upon the season. Data from the two subjects for a year-long measurement in the present study were also compatible with the previous results. There were some trends in the intensity of monthly biophoton emission for a year. However, the fluctuations were rather severe and additional year-long data would be necessary to determine any definite seasonal variations. We focused on the effects of magneto-acupuncture stimuli by combining the year-long data into a set.

The two subjects were different in the photon emissions from the left and right hands. In the case of subject 1, the ASYM-values of dorsal and palm after the stimuli were slightly reduced. In the case of subject 2, the change of the ASYM-value of the dorsal before and after stimuli was rather small while that of the palm was large after the stimuli. In the aspect of traditional oriental medicine, one of the important parameters is the left-right balance of the body. The ASYM-value may represent each person's degree of left-right balance because it is different from individual to individual. In addition, several statistical quantities such as the average intensity, the standard deviation, the δ-value, and the degree of asymmetry show a difference in the value before and after magnetic stimuli. This is not displayed in the group statistical analysis. So we have to investigate the photon emission giving consideration to the characteristics of the individual. This suggestion coincides with that in previous work that the time course of photon emission rates from the hand seemed to show different responses to the

stimuli depending on the subjects [34], and further studies are going on into the relationship between the ultraweak photon emissions and physiological states.

In summary we investigated the effects of magneto-acupuncture stimuli with the detectors for ultraweak photon emissions. The average intensity and its standard deviations for the stimulated group changed significantly compared with those of the control and the sham groups. The individualities of the subjects also increased the difference of photon emissions compared to the above group study before and after magnetic stimuli.

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References

1. Jerabek J, Pawluk W. Magnetic therapy in Eastern Europe: a review of 30 years of research. Chicago: William Pawluk, 1998:149–64.
2. Kim J, Baik K, Lee B, Kang S, Shin S, Soh K. Extremely low frequency magnetic field effects on premorbid behaviors produced by cocaine in the mouse. *Bioelectromagnetics* 2004;25:245–50.
3. Beischer DE. Vectocardiogram and aortic blood flow of squirrel monkeys (Saimiri Sciureus) in a strong superconductive electromagnet. In: Barnothy JM, ed. Biological effects of magnetic fields. New York: Plenum Press, 1969:241–9.
4. Jehenson P, Duboc D, Lavegne T, Guize L, Guérin F, Degeorges M, et al. Change in human cardiac rhythm induced by a 2-T static magnetic field. *Radiology* 1988;166:227–30.
5. Gmitrov J, Ohkubo C, Okano H. Effect of 0.25-T static magnetic field on microcirculation in rabbits. *Bioelectromagnetics* 2002;23:224–9.
6. Vallbona C, Hazlewood CF, Jurida G. Response of pain to static magnetic fields in postpolio patients: a double-blind pilot study. *Arch Phys Med Rehabil* 1997;78:1200–3.
7. Colbert AP, Markov MS. Banerji M, Pilla AA. Magnetic mattress pad use in patients with fibromyalgia: a randomized, double blind study. *J Back Musculoskel Rehab* 1999;12:1–13.
8. Man D, Man B, Plosker H. The influence of permanent magnetic field therapy on wound healing in suction lipectomy patients: a double-blind study. *Plast Reconstr Surg* 1999;104:2261–6.
9. Mayrovitz HN, Groseclose EE, Markov M, Pilla AA. Effects of permanent magnets on resting skin blood perfusion in healthy persons assessed by laser Doppler flowmetry and imaging. *Bioelectromagnetics* 2001;22:494–502.
10. NIH. Acupuncture. National Institutes of Health Consensus Statement 1997;15:1–34.
11. Langevin H, Churchill D, Cipolla M. Mechanical signaling through connective tissue: a mechanism for the therapeutic effect of acupuncture. *FASEB J* 2001;15:2275–82.
12. Langevin H, Yandow J. Relationship of acupuncture points and meridians to connective tissue planes. *Anat Rec (New Anat)* 2002;269:257–65.
13. Lee B, Baik K, Johng H, Nam T, Lee J, Sung B, et al. Acridine orange staining method to reveal the characteristic features of an intravascular threadlike structure. *Anat Rec (Part B: New Anat.)* 2004;2788:27–30.
14. Noordergraaf A, Silage D. Electroacupuncture. *IEEE Trans Biomed Eng* 1973;20:364–6.
15. McCarroll G, Rowley B. An investigation of the existence of electrically located acupuncture points. *IEEE Trans Biomed Eng* 1979;26:177–81.
16. Becker R. The significance of bioelectric potentials. Bioelectrochem Bioenerg 1974;1:187–99.
17. Shang C. Electrophysiology of growth control and acupuncture. *Life Sciences* 2001;68:1333–42.
18. Napadow V, Makris N, Liu J, et al. Effects of electroacupuncture versus manual acupuncture on the human brain as measured by fMRI. *Human Brain Mapping* 2005;24: 193–205.
19. Popp FA, Gu Q, Li KH. Biophoton emission: experimental background and theoretical approaches. *Mod Phys Lett B* 1994;8:1269–96.
20. Devaraj B, Usa M, Inaba H. Biophotons: ultraweak light emission from living systems. *Curr Opin Solid State Mater Sci* 1997;2:188–93.
21. Kohen E, Santus R, Hirschberg JG. Photobiology. New York: Academic Press, 1995.
22. Cohen S, Popp F. Biophoton emission of the human body. *J Photochem Photobiol B* 1997;40:187–9.
23. Kobayashi M, Takeda M, Sato T, Yamazaki Y, Kaneko K, Ito K, et al. In vivo imaging of spontaneous ultraweak photon emission from a rat's brain correlated with cerebral energy metabolism and oxidative stress. *Neurosci Res* 1999;34: 103–13.
24. Levin M. Bioelectromagnetics in morphogenesis. *Bioelectromagnetics* 2003;24:295–315.
25. Yoon YZ, Kim J, Lee B, Kim Y, Lee S, Soh K. Changes in ultraweak photon emission and heart rate variability of epinephrine-injected rats. *Gen Physiol Biophys* 2005;24: 147–59.
26. Kim HW, Sim SB, Kim CK, Kim J, Choi C, You H, et al. Spontaneous photon emission and delayed luminescence of two types of human lung cancer tissues: Adenocarcinoma and Squamous cell carcinoma. *Cancer Lett* 2005;229: 283–9.
27. Kim J, Choi C, Lim J, You H, Sim S, Yom Y, et al. Measurements of spontaneous ultraweak photon emission and delayed luminescence from human cancer tissues. *J Altern Complement Med* 2005;11:879–4.
28. Van Wijk R, Soh KS, Van Wijk EPA. Anatomic characterization of acupuncture system and ultra-weak photon emission. *Asian J Physics* 2007;16:443–72.
29. Van Wijk R, Kobayashi M, Van Wijk EPA. Spatial characterization of human ultra-weak photon emission. *J Photochem Photobiol B* 2006;83:69–76.
30. Yang J, Choi C, Jung H, Woo W, Yi S, Soh K, et al. Left-right and Yin-Yang balance of biophoton emission from hands. *Acupunct Electrother Res Int J* 2004;29:197–211.
31. Jung H, Yang J, Woo W, Choi C, Yang J, Soh K. Year-long biophoton measurements: normalized frequency count analysis and seasonal dependency. *J Photochem Photobiol B* 2005; 78:149–54.
32. Shiavi R. *Introduction to Applied Statistical Signal Analysis*. 2nd ed. San Diego: Academic Press, 1998:110.
33. Choi C, Woo W, Lee M, Yang J, Soh K, Yoon G, et al. Biophoton emission from hands. *J Korean Phys Soc* 2002;41: 275–8.
34. Park S, Koo T, Kim D, Yang J, Yi S, Yang J, et al. Effects of Han-Seo meridian magnetic therapy on biophoton emission. *J Intl Soc Life Info Sci* 2004;22:385–8.