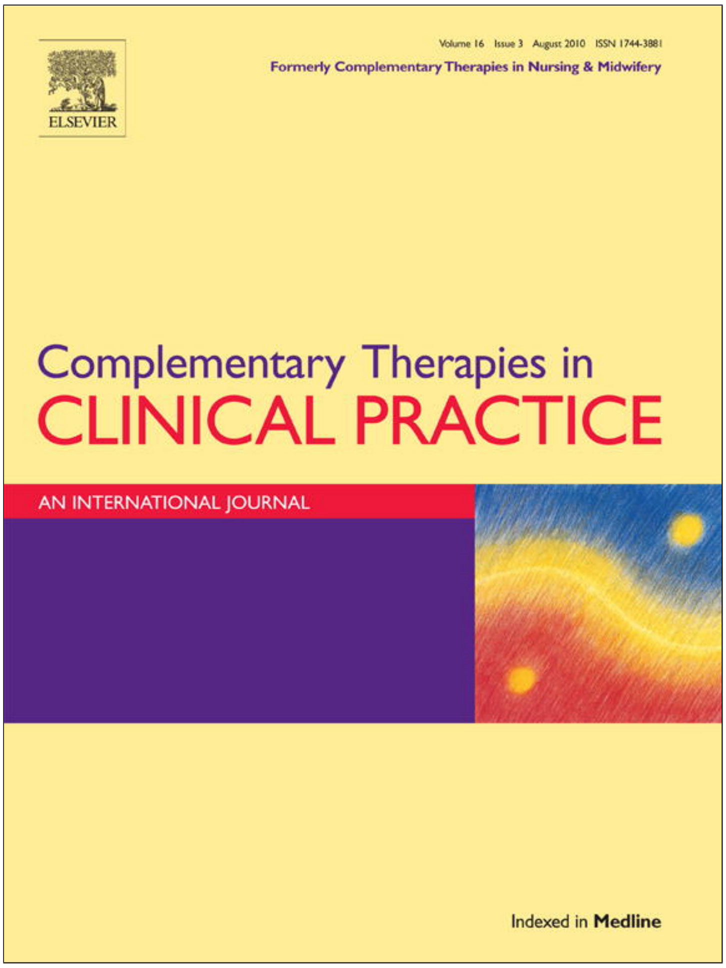
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Increase of electrodermal activity of heart meridian during physical exercise: The significance of electrical values in acupuncture and diagnostic importance

Francesco Pontarollo [a], Giuliana Rapacioli [b], Paolo Bellavite [a,*]

[a] Dipartimento di Scienze Morfologico-Biomediche, University of Verona, Piazza L.A. Scuro 10, 37134 Verona, Italy
[b] Associazione Italiana Omeopatia di Risonanza, Via Natta, 28, 29010 Pontenure, Piacenza, Italy

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ABSTRACT

Electric field measurements of skin potential and electrical currents are physiological indicators of electrodermal activity (EDA) and have been associated with a variety of sensory, cognitive and emotional stimuli. The aim of this study was to investigate the EDA at some hand acupoints before, during and after a physical exercise. EDA of eight points located at the corner of fingernails of hands was measured in 10 healthy young volunteers before, during and after a 14-min acute exercise in a bicycle ergometer. In pre-exercise resting state the parameters were stable and similar between the 8 different tested points, while during exercise a significant increase of current (from 1000–2000 to 4000–8000 nA) was observed, with the maximal values related to the point located on the ulnar side of the little finger, at the base of the nail, corresponding to the Shao chong (HT9) of heart meridian.

1. Introduction

Despite the increase in research on the therapeutic effects of acupuncture, less attention has been devoted to investigations into the physiological basis of acupuncture. Several electronic devices are now used to localize the acupoints and to assist in diagnosing the location of the disease.[1–11] Most of these electrodermal methods utilize as the preferentially skin testing points the first or terminal points of Chinese meridians ("Ting" points), but other points are currently utilized only according to the Voll's electro-acupuncture system.[3,12]

Acupuncture points are frequently described as having distinct electrical properties, including increased conductance, reduced impedance and resistance, increased capacitance, and elevated electrical potential compared to adjacent non-acupuncture points.[11,13–18] Unfortunately, there is little written in orthodox scientific refereed journals on these claims and others have not confirmed these data.[19] Caution is warranted when interpreting results from electrodermal screening devices, also because the normality ranges and the diagnostic specificity of these measures are often uncertain.[5,20–23] There is general consensus that electrodermal activity (EDA) is associated with sympathetic reactivity in response to various stimuli,[24] possibly due to changes in the activity of sweat glands.[25]

Application of EDA measurements in acupuncture research could clarify some important issues regarding the changes occurring in the meridian system during physiological and pathological strains to the body. The quantitative evaluation of electrical current and electric tension of the points would be important to discriminate the homeodynamic oscillation during physiological activities, the pathologic changes and, eventually, the medicinal effects.

The objective of this study was therefore to verify the effect of physical standardized sub-maximal physical effort in healthy subjects. The test apparatus was an Electrophysiological Terminal point (ET), also called 'Performance 2001'.[17] We tested the null hypothesis that all the tested points, located in the hand fingers near the corner of the fingernails, behave in the same way under the physical stress. Due to technical constraints of the protocol involving a series of measurements during time, only four points in each hand could be measured; therefore, we have chosen three points typical of the Traditional Chinese Medicine (TCM) meridian system (lung, heart and triple warmer meridians) and a point which does not belong to the TCM system.

2. Materials and methods

2.1. Testing device

The ET (Med-Tronik, Friesenheim, Germany) is, basically, a digital multimeter, used in this study as amperometer, with variable resolution settable by software (max 30 nA – min 300 nA, in this study 30 nA). It is a class I electromedical device (DIN EN 60

* Corresponding author. Tel./fax: +39 0458027554.
E-mail address: paolo.bellavite@univr.it (P. Bellavite).

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601-1-2:1994/IEC 601-1-2_1993 and TUV certified). This instrument, unlike other devices, does not deliver electrical current to the body in order to detect the impedance variation, but measures directly the endogenous currents in the nA–μA range.

The current measurements were performed using two electrodes:

a) the reference electrode, an ECG-like Ag–AgCl surface electrode, placed on left volunteer's wrist as forceps with a surface of ≈3 × 5 cm; a filter paper damped in physiological saline (0.9% NaCl) was interposed between skin and electrode.
b) During the test, an electrode, an Ag–AgCl point probe electrode (surface ≈2 mm^2), was placed for 2–3 s on the terminal acupuncture points on all the fingers, adjacent to the corners of the fingernails, with a downward force of approximately 200–300 gr.

The single current value is stored only if it is constant after 75 measures, which are automatically recorded. The LCD output displayed the current value and the tension value. Moreover, with a LED diagram, a visual representation of current intensity is given as:

$$\text{LED number} = 3.3 \times \log\left(I_{\text{meas}} \times 10^8\right)$$

2.2. Test procedure

The 10 tested subjects (7 male, 3 female, mean age 35.0 ± 4.0), were recruited on a voluntary basis in the medical students and laboratory employees. They were all healthy subjects, nonsmokers with no alcohol, drug abuse, acute or chronic pathologies, allergies or psychiatric disease. All participants signed an informed consent at the enrolment.

To assure an optimal testing procedure, the tester was a physician who was trained in the ET technique of EDA measurements, but who was totally unaware of the TCM medicine theory of acupuncture meridians. In this way, the tester was "blind" to the meaning of the different tested points and there was no possibility that their (even unconscious) expectation could influence the pressure exerted or the way by which the electrodes were placed or used on the different acupoints.

The test was performed on skin points in each hand, situated at the tips of the fingers, near the corners of the fingernails (Fig. 1). Due to technical constraints of the protocol, and specifically to the need of measuring in triplicate a number of points during resting and exercise at time intervals, four points in each hand were tested, for a total of eight acupoints (Table 1).

Fig. 1. Measurement of electric current with point electrode at the corner of the fingernail (point n. RH-1, see Table 1).

Before every test the probe was damped on physiologic solution and the accepted measure were immediately registered. The entire measure's series of eight points was repeated three times for every session.

The physical stimulus was a standardized cycle ergometer session for 14 min at sub-maximal strain (corresponding to a 70% of the maximal cardiac frequency related at the subject age). The measurements were done at 7-min time intervals before, during and after the exercise. Zero time was taken as the baseline measure.

2.3. Statistics

All analyses were performed using the SPSS software, version 17 (SPSS Inc., Chicago, IL, USA: http://www.spss.com). Normality was checked by the Shapiro–Wilk test. Data distribution of current (nA) were often asymmetrical, then the values of different points and times are computed and reported as box plots showing 10th, 25th, 50th (median), 75th and 90th percentile. For the global analysis of the changes of current during different times and of the differences between various detection points at the peak time we adopted the Friedman non-parametric test for multiple related samples. Since all these comparisons were significant, a post-hoc analysis of the differences between the peak values of different points was performed using the 2-tailed Wilcoxon non-parametric test for related samples. Data distributions of tension (mV) were normal, so that oneway analysis of variance (ANOVA) could be applied for this parameter. P values < 0.05 were considered as statistically significant.

3. Results

A total of 10 individual tests were completed, each one in triplicate. Fig. 2 shows the current on every point, measured at 7-min time intervals before (3 measurements), during (2 measurements) and after (3 measurements) exercise. At baseline (time zero) the mean values of the eight points gave similar values in the three separate and consecutive trials performed on each subject. Current intensity varied from a minimum of about 1000 nA to a maximum of about 2000 nA, depending on different points, with good repeatability between the three tests. None of the detected points showed a significant difference between males and females (not shown).

The exercise clearly enhanced the current values on all the points, with the maximal increase related to RH-9 and LH-19 points, located on the radial side of the tip of the small finger, about 0.1 cun posterior to the corner of the fingernail. Global Friedman analysis of time course current values was significant ($p < 0.001$) in each point.

We then evaluated the differential change in EDA (current) by subtracting – for each point and each subject – the values of baseline (time zero) to the corresponding value obtained at the peak time (time 28 min). The results of this analysis are reported in

Table 1
Locations and names of the tested points.

Point number	Finger	Side	TCM[a] Meridian	TCM[a] classification
RH-1	1 Right (thumb)	Radial	Lung	Shaoshang (LU11)
RH-4	2 Right	Ulnar	–	–
RH-8	4 Right	Ulnar	Triple burner	Guanchong (SJ1)
RH-9	5 Right	Radial	Heart	Shaochong (HT9)
LH-11	1 Left (thumb)	Radial	Lung	Shaoshang (LU11)
LH-14	2 Left	Ulnar	–	–
LH-18	4 Left	Ulnar	Triple burner	Guanchong (SJ1)
LH-19	5 Left	Radial	Heart	Shaochong (HT9)

[a] TCM: Traditional Chinese Medicine.

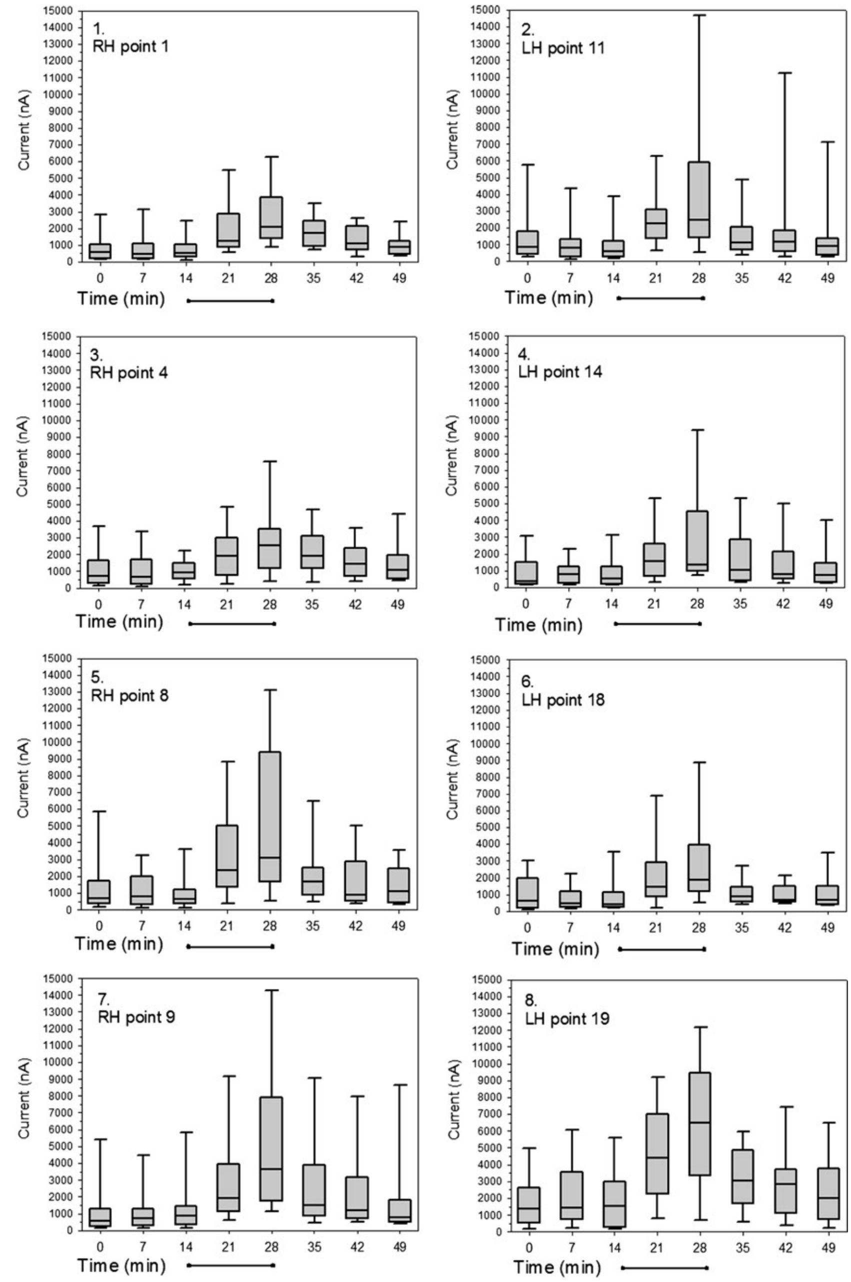

Fig. 2. Changes of current flux at the indicated acupoints of 10 healthy subjects during sub-maximal physical strain on cycloergometer. The bar indicates the period during which the exercise was done.

Table 2, which includes the Wilcoxon test. Both mean and median EDA of the points RH-9 and LH-19 were higher than those of other points and the difference was highly significant ($p < 0.01$) when the responses of these two points to exercise were compared to the points RH-1, RH-4, RH-11, RH-14. The LH19 point (left hand) showed the maximum values, but difference between two symmetrical points RH-9 and LH-19 was not statistically significant.

Fig. 3 shows the tension of the endogenous electric field between the electrodes on every point, measured at the same intervals before, during and after exercise. The tension varied from a minimum of about 80 mV to a maximum of about 240 mV. In all the points, there was a slight decrease in the pre-exercise phase, followed by a small increase just after the beginning of the exercise, then the values returned near to baseline after exercise. These changes during time in each point were statistically significant;

Table 2
Differences of current between the peak (time 28 min) and time 0 in various detection points.

Point	Current (nA)			Wilcoxon[a]	
	Mean	S.E.M.	Median	RH-9	LH-19
RH-1	2052.8	337.6	1403.7	**	***
RH-4	1794.0	322.3	1754.2	***	***
RH-8	3557.2	587.2	2442.2	*	n.s.
RH-9	4239.1	666.6	2875.8	–	n.s.
LH-11	3002.1	751.1	1298.0	n.s.	*
LH-14	1838.0	396.8	912.7	**	***
LH-18	2144.4	538.2	1333.0	**	**
LH-19	4742.7	583.0	4971.0	n.s.	–

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

[a] Comparison of median values of points RH-9 and LH-19 with all other points.

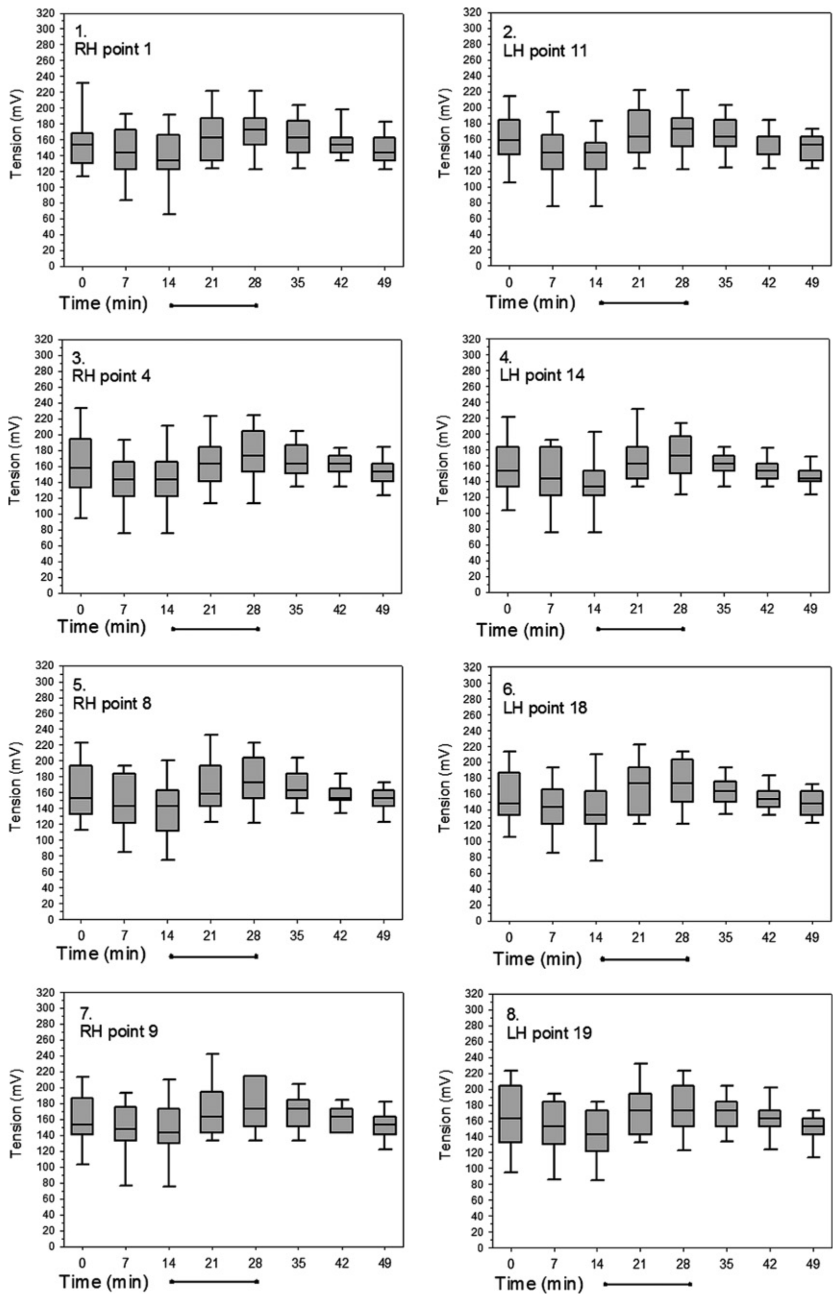

Fig. 3. Changes of electric potential tension at the indicated acupoints of 10 healthy subjects during sub-maximal physical strain on cycloergometer. The bar indicates the period during which the exercise was done.

however, upon ANOVA analysis there were no significant differences in the kinetics behavior of tension or in the peak values of the different points.

4. Discussion

Electrodermal instruments are widely used throughout the world and many non-health professionals and also some doctors believe that EDA techniques are valuable part of the clinical practice, because of their safety, non-invasive nature, simplicity, cost-effectiveness and clinical value. However, much preliminary work on the diagnostic value of these instruments has still to be confirmed. Our analysis of various parameters of EDA in healthy subjects indicates that acupuncture points may reveal statistically significant differences in the current flow through specific acupoints following a sub-maximal physical strain.

So, the null hypotheses of no specific changes of acupoints during exercise are disconfirmed and evidence suggests that the electrical values are associated to real physiological conditions and, thus, have a diagnostic importance.

There is no specific anatomic structure related to all the acupuncture loci, but a preferential distribution has been established according to the loci and their therapeutic correlates.[26] Analysis of EDA responsiveness of acupoints along meridians would be of importance for establishing new correlates between traditional experience and health/disease conditions.

Our findings cannot be attributable to increased electric tension between electrodes, that was similar in all tested acupoints, nor to unspecific electric skin changes, due for example to increased sweating for the following reasons: (a) both electrodes are deeply damped in physiological saline before use, thus the relative humidity of skin should be uninfluential on the measure, (b) the EDA activity increases quickly after the beginning of exercise (before the start of sweating) and decreases quickly after exercise (when the perspiration is still very active).

The clear growth of EDA of RH-9 and LH-19 points, corresponding to the heart Meridian according to the Traditional Chinese Medicine (SHAO CHONG points), confirms a possible correlation between physiological activation of cardiocirculatory system and the electrical state of specific skin points. Overall, these findings are in agreement with the views[11,19,24,27–29] according to which EDA may become an important parameter in acupuncture studies.

Competing interests

Authors have no competing interests. F. Pontarollo was financed by a scholarship from Verona University. G. Rapacioli is independent researcher. P. Bellavite is a Verona University employee.

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References

1. Ali M. Correlation of IgE antibodies with specificity for pollen and mold allergy with changes in electrodermal skin responses following exposure to allergens. *Am J Clin Pathol* 1989;**91**:357.
2. Ionescu-Tirgoviste C, Pruna S. Quantitative noninvasive electrophysiological evaluation of the activity of the cutaneous division of the sympathetic nervous system. *Arch Int Physiol Biochim* 1990;**98**:111–9.
3. Schimmel H, Penzer V. Functional medicine. In: *The origin and treatment of chronic diseases*, vol. 1. Heidelberg: Haug Verlag; 1996.
4. Krop J, Swiicezek J, Wood A. Comparison of ecological testing with the Vega test method in identifying sensitivities to chemical foods and inhalants. *Am J Acupunct* 1985;**13**:253–9.
5. Lewith GT. Can we evaluate electrodermal testing? *Complement Ther Med* 2003;**11**:115–7.
6. Krop J, Lewith GT, Gziut W, Radulescu C. A double-blind, randomized, controlled investigation of electrodermal testing in the diagnosis of allergies. *J Altern Complement Med* 1997;**3**:241–8.
7. Fuller Royal F. Understanding homeopathy, acupuncture and electrodiagnosis. Clinical applications of quantum mechanics. *Am J Acupunct*; 1990:18–53.
8. Lam FMK, Tsuei JJ, Zhao Z. Study on the bioenergetic measurement of acupuncture points for determination of correct dosages of allopathic and homeopathic medicines in the treatment of diabetes mellitus. *Am J Acupunct* 1990;**18**:127–33.
9. Tsuei JJ, Lechman CW, Lamb FMK, Zudh A. A food allergy study using the EAV acupuncture technique. *Am J Acupunct* 1984;**12**:105–16.
10. Chaltin L. Clinical homeopathy, bioallergic remedies, and electroacupuncture devices. *Townsend Lett* 1994;**126**:38–42.
11. Ahn AC, Martinsen OG. Electrical characterization of acupuncture points. Technical issues and challenges. *J Altern Complement Med* 2007;**13**(8):817–24.
12. Voll R. Twenty years of electroacupuncture diagnosis in Germany. A progress report. *Am J Acupunct* 1975;**3**:7–17.
13. Kenyon JN. *Modern techniques of acupuncture*, vol 3. Wellinborough: Thorson Publ. Ltd; 1983.
14. Tiller W. What do electrodermal diagnostic acupuncture instruments really measure? *Am J Acupunct* 1987;**15**:15–23.
15. Fuller Royal F, Fuller Royal D. Scientific support for electrodiagnosis. Relationship to homoeopathy and acupuncture. *Br Homeopath J* 1991;**80**:166–78.
16. Van Wijk R, Wiegant FAC. *Homeopathic remedies and pressure-induced changes in the galvanic resistance of the skin*. Alkmaar (The Netherlands): VSM Geneesmiddlen; 1989.
17. Eichorn R, Schimmel H. Die elektrophysiologische Terminalpunktdiagnose. *Biol Med* 1998;**27**:220–2.
18. Chen J, Ma S. Effects of nitric oxide and noradrenergic function on skin electric resistance of acupoints and meridians. *J Altern Complement Med* 2005;**11**:423–31.
19. Pearson S, Colbert AP, McNames J, Baumgartner M, Hammerschlag R. Electrical skin impedance at acupuncture points. *J Altern Complement Med* 2007;**13**(4):409–18.
20. Watkins AD. The role of alternative therapies in the treatment of allergic disease. *Clin Exp Allergy* 1994;**24**:813–25.
21. Lewith GT, Kenyon JN, Broomfield J, Prescott P, Goddard J, Holgate ST. Is electrodermal testing as effective as skin prick tests for diagnosing allergies? A double blind, randomised block design study. *Br Med J* 2001;**322**:131–4.
22. Semizzi M, Senna G, Crivellaro M, Rapacioli G, Passalacqua G, Canonica WG, et al. A double-blind, placebo-controlled study on the diagnostic accuracy of an electrodermal test in allergic subjects. *Clin Exp Allergy* 2002;**32**(6):928–32.
23. Wuthrich B. Unproven techniques in allergy diagnosis. *J Investig Allergol Clin Immunol* 2005;**15**(2):86–90.
24. Vickland V, Rogers C, Craig A, Tran Y. Electrodermal activity as a possible physiological marker for acupuncture. *Complement Ther Clin Pract* 2008;**14**(2):83–9.
25. Tronstad C, Gjein GE, Grimnes S, Martinsen OG, Krogstad AL, Fosse E. Electrical measurement of sweat activity. *Physiol Meas* 2008;**29**(6):S407–15.
26. Bossy J, Maurel JC, Godlewski G. Macroscopic substratum of acupuncture points. *Bull Assoc Anat (Nancy)* 1975;**59**:357–62.
27. Yu HM, Chang HH, Liou SY, Li SF, Hou MM, Chen MF. The correlation between skin electrical conductance and the score of qi vacuity. *Am J Chin Med* 1998;**26**(3–4):283–90.
28. Weng CS, Hung YL, Shyu LY, Chang YH. A study of electrical conductance of meridian in the obese during weight reduction. *Am J Chin Med* 2004;**32**:417–25.
29. Sancier KM. Electrodermal measurements for monitoring the effects of a qigong workshop. *J Altern Complement Med* 2003;**9**(2):235–41.