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PRELIMINARY RESULTS OF A NEW METHOD FOR LOCATING AURICULAR ACUPUNCTURE POINTS

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ABSTRACT:

Auricular acupuncture is widely used for the treatment of cocaine addiction, and there is an urgent need to conduct controlled clinical research of this intervention. One impediment to this endeavor is the lack of an objective and reliable method for identifying the hypothesized active and control points. In order to address this issue, we conducted two studies employing a constant current electrical device and a novel probing technique. In the first study, we assessed the reliability of our technique for measuring electrical skin resistance points (acupuncture or non-acupuncture) on the body and auricles. In the second study, we analyzed and compared the measurements of skin resistance of auricular acupuncture and control zones in a group of cocaine abusing patients. Findings suggest that our measurement method produced reliable measurements, and that active acupuncture zones revealed a significantly different pattern of electrical skin resistance readings compared to control zones. This method may be useful for locating active and control points in controlled clinical trials of auricular acupuncture.

Key Words: acupuncture; addiction; electrical resistance; cocaine; methadone.

INTRODUCTION

In the research and clinical literature, acupuncture points have been characterized as discrete anatomical loci [1,2,3,4] measuring approximately 1-6 cm in diameter on the body [5,6,7, 8], and 1-5 mm in diameter in the auricles and other "microsystems" [9,10,11]. Relative to the minute dimensions of the acupuncture needle tip, these loci, hereafter referred to as "point-zones," are sufficiently large regions such that they contain a multitude of possible points for needle insertion. A basic tenet of acupuncture practice is that within each point-zone there exists a specific sub-region or point that constitutes the optimal site for needle insertion, yielding the most "effective" or most "active" treatment effect [12,13,14]. Historically, specific sites for needle insertion were located by anatomical landmarks [e.g. 4], or on the basis of pressure-pain, or de qi sensations [e.g. 11,14]. One disadvantage to this approach is that the site of needle insertion is determined by a relatively subjective method.

The use of subjective, and potentially unreliable, methods, for locating acupuncture points is problematic for several reasons. There is a call by Western scientists and regulatory agencies for the investigation of acupuncture's efficacy in controlled, randomized clinical trials. For example, in the field of addiction medicine, the area of concentration of our research group, auricular acupuncture is one of the fastest growing treatments [15]; however, researchers in this field continue to view acupuncture as an "unproven" form of treatment [16]. Controlled trials mandate the use of techniques to assure the integrity of the independent variable -- the treatments -- both for the active treatment and control groups. However, problems concerning the objective location of points for needle insertion in the relatively small auricle point-zones has not, to our knowledge, been addressed. This makes it difficult to ensure that adequate treatments are delivered, and that active and control points are subsets of non-intersecting domains, in clinical trials of auricular acupuncture.

One promising advance upon subjectively based point location methods was made in the twentieth century with the introduction of electrodermal measurements [e.g. 11,17] to locate points of low skin resistance [18]. This technique was based on the observation that acupuncture points apparently coincide with points of low electrical resistance (ER). Although several studies have lent support to this claim [e.g. 6,19, for a review see 20], a number of questions have also been raised concerning the technical and methodological foundations of this area of research; in particular, the method used to measure electrical resistance, and the skin/measurement device interface [21,22]. Our research group has been investigating electrical "point-location" devices for use in conducting controlled research of auricular acupuncture for the treatment of cocaine addiction. Here we report on these investigations to date.

We note that two primary approaches have been used to measure the electrical resistance of the skin. One applies a fixed (or constant) voltage across the measurement and reference electrodes, and measures the electric current flowing through the tissue. The second applies a fixed (or constant) current, and measures the voltage between the measurement and reference electrodes. Prior to conducting the study reported here, we sampled ten commercially available devices designed to locate low-resistance points (i.e., acupuncture points) and found that they all employ a constant voltage circuit [Falk & Birch (unpublished findings)]. One characteristic of this circuit is that the electric current delivered by the device varies as a function of skin resistance. This presents a number of problems: for example, relatively lower skin resistance yields higher currents (which can reach milli-ampere range with these devices) that may cause changes in the tissues from which the measurements are taken, possibly reducing ER and potentially injuring those tissues [23]; the varying currents will differentially affect or stimulate the points being measured. This suggests that constant current in the micro-ampere range, rather than a fixed voltage, should be employed -- it will minimize electric damage to the skin tissue while remaining substantially above the levels of bio-electrical background noise (in the nano-ampere range) of biological systems. Constant current methods have also been found to possess less variability in resistance measurements compared to constant voltage methods [24]. A biphasic current [25], preferably of low frequency [23], is also recommended to prevent injury to the tissue being evaluated.

Another important issue in measuring electrodermal points of low electrical resistance concerns the probing technique -- that is, the skin/measurement device interface. When a metallic probe is held in direct contact with skin, the ER measurement may fluctuate or drop due to pressure artifacts induced by the probe [25, 26, 27], mechanical injury of the skin, or electrochemical reactions of the skin with the probe [27,28]. In order to obviate these problems, some researchers have employed spring-loaded probes, thereby obtaining more control over the applied pressure. However, we conducted preliminary investigations using spring-loaded probes and found that these devices may not permit sufficient control of the pressure to eliminate fluctuations or drops in electrical resistance measurements [Falk & Birch, (unpublished findings)]. In order to address this problem we decided to use a viscous contact medium, a gel, as an electrical bridge between the skin and the probe, assuring the identification of the point across repeated measures by marking the target point with ink. The use of this technique, although potentially advantageous because of eliminating contact of the probe with the skin, raised a number of issues, which we sought to address in this study. These issues bear upon the possible introduction of artifacts due, for example, to small variations in the surface area of skin covered by the gel which could potentially produce significant variations in skin ER readings, or by the possible interaction of the ink with the gel, as well as with the point.

The current study, in addition to addressing the above technical issues, also sought to investigate the application of this measurement technique to both acupuncture and control points used in clinical trials of acupuncture for treatment in the addictions. We therefore measured electrical skin resistance using this technique with respect to two types of auricular points: 1) "active" points primarily located in the ear concha used in the treatment of the addictions; and 2) putative "inactive" points on the ear helix [29]. These represent the two sets of points that have been employed in clinical trials of acupuncture for cocaine addiction. Readings from these two sets of points were compared in order to characterize electrical properties of acupuncture points in relation to control points. The analyses included in this paper were designed to answer questions that are likely to be of fundamental importance when conducting clinical trials of acupuncture: is the electrical skin resistance of acupuncture points significantly different from that of inactive points; if it is, to what degree; is the measurement technique reliable, i.e., do repeated measurements of the same point yield constant values?

These studies were conducted as part of a broader investigation preliminary to conducting a clinical trial of auricular acupuncture for the treatment of cocaine dependence [30]. The application of auricular acupuncture for treatment in the addictions was originated in the U.S. by Dr. Yoshiako Omura, and subsequently by Dr. Michael Smith, in the 1970's at Lincoln Hospital, New York [31]. In the past thirty years, auricular acupuncture has become a widely used treatment, in the U.S. and worldwide, for the treatment of cocaine addiction. However, randomized clinical trials of this treatment modality have shown somewhat conflicting findings, perhaps due in part to the use of inappropriate – that is, too active – control conditions [32]. This underscores the importance of determining an objective and reliable method for differentiating active and control sites in the auricle.

Methods

Subjects.

A. Reliability Study.

Subjects were four apparently healthy research staff members with no history of drug abuse; 75% were female, with a mean (±SD) age 33.8 (±3.8). Because the goal of the reliability study was to determine the repeatability of electrical skin resistance measurements at the same points, each point was considered independent from other points both on the same subject and across subjects. Twenty-four skin points (between 4 and 10 points per subject) were chosen at random for measurements on the hands and auricles.

B. Study of Cocaine Abusing Patients.

Thirty-four methadone-maintained individuals with a history of cocaine abuse were recruited from methadone maintenance programs located in New Haven, Connecticut. The mean age of the subjects was 36.7 (±6.7) years. The sample was 50% male and 50% female. The racial composition of the sample was 41% Caucasian, 29% African American, and 29% Hispanic. On average, subjects had been using cocaine for 10.9 (±7.0) years. Subjects were paid $10 for their participation in the study.

Materials and equipment. In order to address problems associated with existing devices, noted above, a device was specifically designed and constructed for these studies by one of the authors (Y.T.). This device (Human Body Impedance Tester, Neurological Corporation, Gaithersburg, MD), delivered a constant current of 2.5 micro-amperes in the form of biphasic AC square pulses of 5 Hz frequency. It contains a negative feedback circuit which assures linear measurements over a range from approximately 2 kilo-ohms to 20 mega-ohms. Measurement and reference electrodes were of Ag-AgCl composition [25, 33]. Two reference electrodes (0.79 cm^2 each) were employed in parallel with one placed on the back of each hand. The diameter of the measurement electrode was about 1 mm; contact with the skin was made through a mound of contact gel covering a skin area of approximately 1 mm^2. UFI Biogel was used as the contact medium (ingredients: purified water, 1,2-propanediol, carboxylate polymer, citrate salt; specifications: resistance, 14.0 ohms; pH, 6.25; viscosity, 1,250,000 cps; density, 1.06 gm/ml). Pilot brand point pens were used to mark the points. [For a schematic diagram of the experimental set-up, see Figure 1, below].

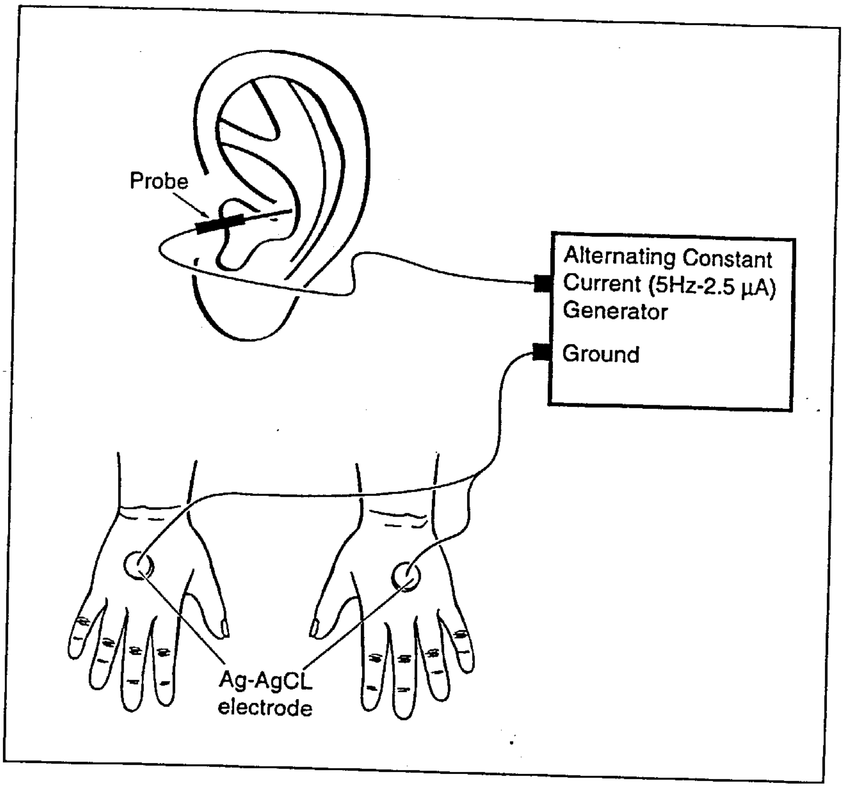

Figure 1. Experimental Setup

Procedure

A. Reliability Study.

Points on either the auricles or hands were chosen at random and cleaned with 70% isopropyl alcohol. The area surrounding the point was outlined with a permanent marker, and the specific site to be measured was either marked with a washable ink marker or unmarked. A mound of gel was carefully applied with a 27G blunt syringe needle to the point for each series of measurements. Two series of measurements of electrical resistance, comprising two repeated individual measurements, were made on each point, one in which the target point was marked with ink and the other in which it was not. Pressure on the point was avoided by having the measurement electrode contact only the gel. The two series were administered in a random sequence. After the first series was completed, the gel, as well as the ink mark, if previously applied, was gently wiped off with a soft tissue, leaving only the permanent mark surrounding the point. A new mound of gel was reapplied, as well as an ink mark if called for by the series. Measurements in both series were made within the time period of 2-10 minutes after the gel application (preliminary investigations indicated that the ER readings stay relatively consistent within this time period).

B. Study of Cocaine Abusing Patients

Each subject was seated comfortably in a chair. Both auricles and the backs of both hands were cleaned with 70% isopropyl alcohol. After a 2-minute drying period, one reference electrode was affixed to the back of each hand using Biogel as the contact medium. Four points (representing four quadrants in a 2x2 array, except for the "Sympathetic" point-zone which had 3 points along a line) within each of eight zones were marked with a washable ink pen by an acupuncturist, as shown in Figure 2.

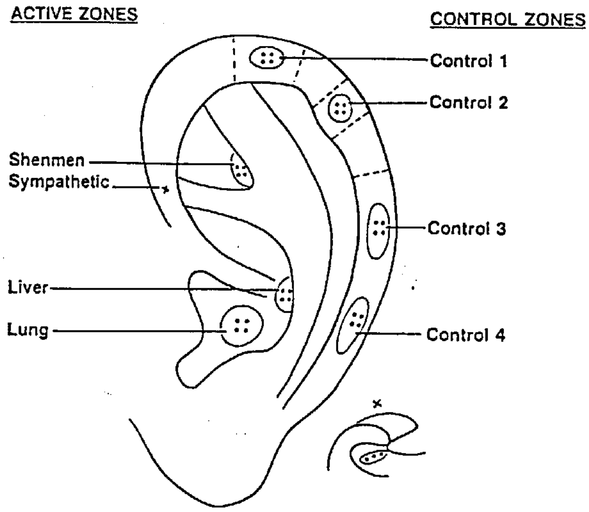

Figure 2. Auricular map of acupuncture zones including four active zones (Lung, Liver, Shenmen, and Sympathetic) and four control zones (Control 1-4) on the helix. The arrangement of the four points (3 points in Sympathetic zone) within each zone is displayed here.

The eight zones comprise 4 "active" point-zones (Lung, Liver, Shenmen, and Sympathetic) and 4 "control" point-zones (Control 1-4) on the helix. A mound of gel was carefully applied with a 27G blunt syringe needle to each marked point on one auricle; electrical measurements of skin resistance were then made for each point. The same procedure was then repeated for the other auricle. The time lapse between the application of the gel to a point and the

ER measurement reading of that point was reasonably consistent for all the points in eight zones -- about 3-5 minutes. As we noted above, we found that the ER readings tend to be stable during this time period.

Results

Measurements using a stainless steel spring-loaded probe were compared with the gel/Ag-AgCl probing method. Figure 3 shows that with the spring-loaded probe, without gel, the real-time recording of the resistance readings does not level off but continuously drops, while our probing method produced more stable readings.

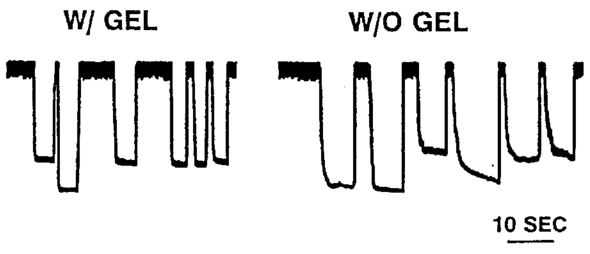

Figure 3. Real-time recording of electrical skin resistance measurements at six points on an auricle.
Left: recording using Ag-AgCl electrode with contact gel; Right: recording using stainless steel Spring-loaded probe without contact gel.

A. Reliability Study

Two series of ER measurements (with 2 measurements in each series) were made at each point, yielding a total of 96 measurements. The measurements for the two series combined ranged from 0.71 to 6.46 mega-ohm with a mean of 3.39 ±1.76 mega-ohm. The series without the ink applied prior to the gel application yielded a mean of 3.48 ±1.66 mega-ohm while the series with the ink yielded a mean of 3.30±1.87 mega-ohm. No significant differences were found between the two series. These results suggest that neither successive gel applications nor use of the ink marker introduce additional error into the measurement method. The reliability of the measurement was further evaluated, using correlation analysis. The intra-class correlation was 0.98 for the no ink series and 0.97 for the ink series. The inter-class correlation between the two series was 0.97.

B. Study of Cocaine Abusing Patients

Measurements of skin ER at 4 points (3 points in the Sympathetic point-zone) across eight auricular point-zones (see Figure 1) were collected from 34 cocaine-abusing patients.

The main goals of the analyses done here were to determine if the "active" point-zones can be clearly differentiated from the "control" point-zones in terms of their electrical properties and if there are points of distinctly low resistance in acupuncture zones. Since there are some questions about the accuracy of measurements in the Sympathetic point-zone due to its difficult accessibility, the analyses were conducted both including and excluding the data from the Sympathetic point-zone.

The lowest value (Min) and the highest value (Max) as well as the averaged value (Mean) of the four measurements within each point-zone were calculated and then averaged across "active" acupuncture point-zones and "control" point-zones in both auricles, respectively, to obtain Min_{active}, Max_{active}, $Mean_{active}$, and $Min_{control}$, $Max_{control}$, $Mean_{control}$; the mean and standard error of the mean of the above values across 34 subjects are shown in Figure 4.

Within-Zone Means, Maxima, and Minima

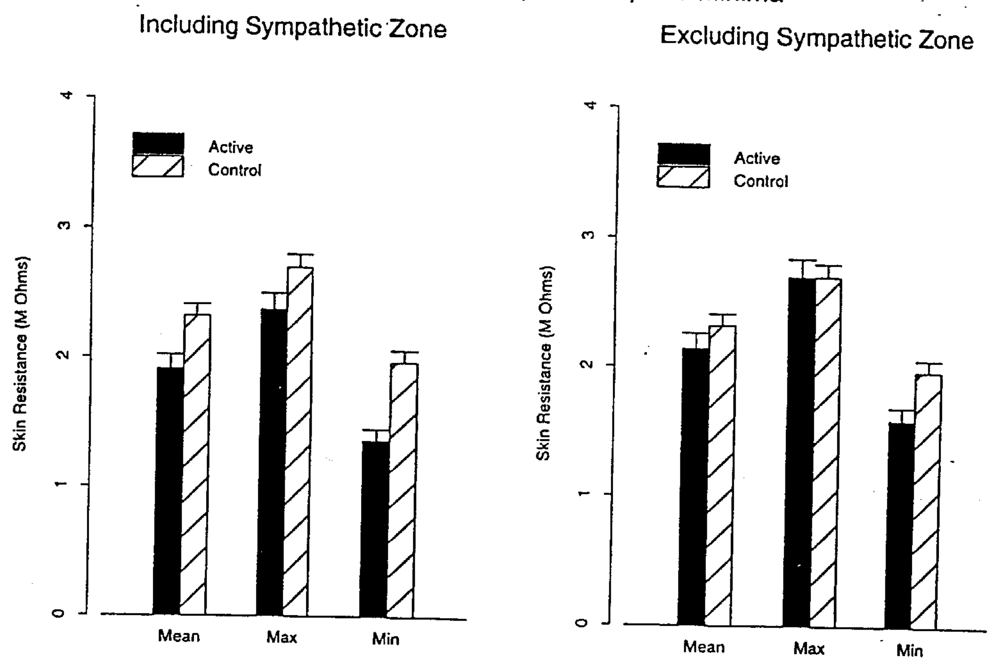

Figure 4. The lowest value (Min) and the highest value (Max) as well as the averaged value (Mean) of the four measurements within each zone were calculated and then averaged across active acupuncture zones and control zones in both auricles respectively, to obtain Min_{active}, Max_{active}, $Mean_{active}$, and $Min_{control}$, $Max_{control}$, $Mean_{control}$; the mean and standard error of mean of the above values across 34 subjects are shown here. **Left**: result including the data from the Sympathetic zone [$Mean_{active}$, 1.91($\pm$0.11) mega-ohm; Max_{active}, 2.37($\pm$0.13) mega-ohm; Min_{active}, 1.36($\pm$0.09) mega-ohm]; **Right**: result excluding the data from the Sympathetic zone [$Mean_{active}$, 2.14($\pm$0.12) mega-ohm; Max_{active}, 2.70($\pm$0.14) mega-ohm; Min_{active}, 1.59($\pm$0.10) mega-ohm]; **Both**: the values for control zones [$Mean_{control}$, 2.32($\pm$0.09) mega-ohm; $Max_{control}$, 2.70($\pm$0.10) mega-ohm; $Min_{control}$, 1.97($\pm$0.09) mega-ohm].

On the left side is the result including the data from the Sympathetic point-zone; while the result shown on the right side did not include the data from the Sympathetic point-zone. In both cases, t-tests show that Min_{active} and $Mean_{active}$ were statistically lower ($p<0.05$) than their control counterparts -- $Min_{control}$ and $Mean_{control}$; while Max_{active} was not significantly different ($p>0.48$) from $Max_{control}$ when the data from the Sympathetic zone was not included (Excluding Sympathetic zone, Min: $t_{33}=-4.36$; Mean: $t_{33}=-1.83$; Max: $t_{33}=0.032$). In fact, the highest readings (Max) were very similar between the active zones and control zones when the Sympathetic data were excluded. This suggests the possibility that the highest readings in each auricular point-zone represent the baseline level of skin ER in the auricles, while the lower readings reflect the difference in skin ER between the two types of zones, hypothetically active acupuncture zones versus control zones.

To better understand the relationship among the four measurements within individual zones, the measurements were sorted as four levels (lowest, next lowest, next highest, and highest) and the pattern of decline from the highest to lowest ER reading was assessed separately for "active" point-zones and "control" point-zones across all 34 subjects. The result (excluding the Sympathetic point-zone) is displayed as the histogram in Figure 5. It shows that in both "active" and "control" point-zones, the decline from the highest to the lowest reading is linear, except that it has a steeper slope with the "active" point-zones.

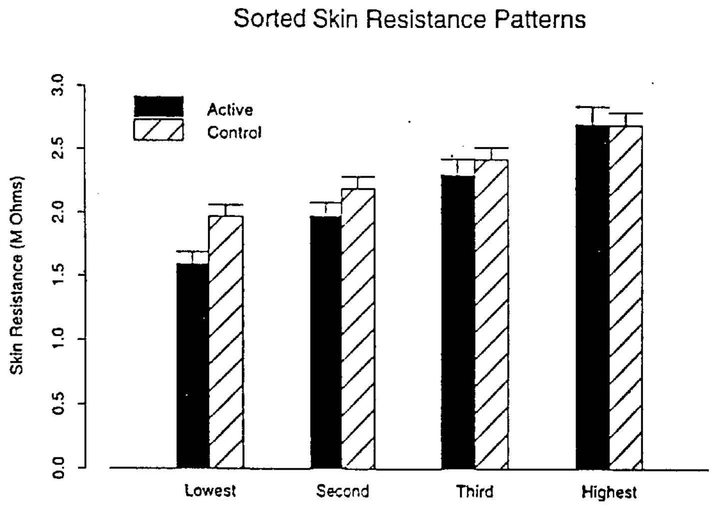

Figure 5. The four ER values within each zone are sorted into four levels (lowest, next lowest, next highest and highest); each level was averaged for all active zones and all control zones in both auricles respectively for each subject; then the means and the standard errors of mean of the four different levels were calculated for both types of zones across all 34 subjects. The Sympathetic data is excluded here because (1) it has only three measurements; (2) there are some questions about the accuracy of measurements in this zone due to its difficult accessibility.

Discussion

We evaluated the reliability of skin ER measurement method based on a constant current device using a contact medium as a skin/probe interface. The results of this study suggest that successive applications of the contact medium on the same point does not create greater variability than the variability of repeated measurements following a single gel application, indicating that our gel application procedure is sufficiently consistent and does not introduce additional error to the measurement. The correlation of 0.97 shows that the measurement method is highly repeatable. Both theoretical considerations and the results of this study suggest that the constant current device as well as the novel probing technique provides good measurement consistency across different points. The use of this method in research studies should produce reliable data concerning the electrical properties of acupuncture points.

The study of cocaine abusing patients is an application of this measurement method. Results from this study suggest the following characteristics for the active acupuncture point-zones: a) the highest ER readings are similar to those from the control zones, possibly representing the baseline level; b) both mean and the lowest ER values are significantly lower than the counterparts from the control zones; c) the decline from the highest to the lowest ER reading is linear for both types of zones and the slope of decline is steeper in the active zone than in control zone. Based on these findings, it is reasonable to hypothesize that in the active acupuncture zones a point of low resistance is more distinct relative to the neighboring area and more likely to be detected than in control zones. The linear quality of the slope suggests the low resistance point is not discrete, but rather there is a gradual decline from the neighboring area to a point of low resistance. These findings provide some evidence for the claim that an acupuncture point has lower skin ER than the surrounding area. However, such a drop in resistance relative to the neighboring area (or the baseline level) does not seem to be as dramatic as has been reported elsewhere [e.g. 34]. It is possible that other researchers have found relatively large drops in skin resistance, for example, as low as 10 kilo-ohm [19,35], due to confounding factors, such as pressure artifacts from the metal probe, or because points of relatively lower skin ER yield larger current flows (when constant voltage is applied), which will tend to decrease the skin ER.

Although our findings may contribute to the further understanding of the electrical properties of auricular acupuncture point-zones, they do not address the questions of whether the "active" acupuncture point-zones versus the "control" point-zones, or the low ER points versus the neighboring area, can be differentiated clinically or therapeutically. Further studies as well as clinical trials are needed to address these issues. We note that one potential limitation of our reliability study is that ink/no ink condition was studied simultaneously with reapplication of gel, in which the two variables might interact. However, since reapplication of gel did not introduce greater variability with or without consideration of ink usage, it is unlikely our findings are confounded by this interaction.

We recognize that our measurement method, especially the probing technique, is not optimized for use in a large-scale clinical trial because the procedure of gel application is time consuming. If it is to be employed in clinical research, some modifications may be needed. For instance, a disposable, Ag-AgCl, electrode-probe array, containing a contact medium on each electrode, with each electrode insulated from other electrodes, could be designed and manufactured. Other constant-current techniques reported in the literature, for example using dry roller electrodes [24], appear promising for reliably locating sites of low-resistance, but may not be feasible for use on the ear due to its topographical irregularities and relatively small size. In our opinion, further work in this area is important, because acupuncture efficacy research has suffered from a lack of validation of the active and control conditions.

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