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Electrical Skin Impedance at Acupuncture Points

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ABSTRACT

Objective: To test whether electrical skin impedance at each of three acupuncture points (APs) is significantly lower than at nearby sites on the meridian (MP) and off the meridian (NP).

Design: Two instruments—Prognos (MedPrevent GmbH, Waldershof, Germany), a constant-current (DC) device, and PT Probe (designed for this study), a 100-Hz sinusoidal-current (AC) device—were used to record electrical impedance at three APs (right Gallbladder 14, right Pericardium 8, and left Triple Energizer 1), and two control sites for each AP. Each AP, MP, and NP was measured four times in random order with each device.

Setting: The study was conducted over a period of 4 days at the Oregon College of Oriental Medicine (OCOM).

Subjects: Twenty (20) healthy adults (14 women and 6 men), all recruited from the OCOM student body and faculty, participated in the study.

Results: The Prognos measurements had an intraclass correlation (ICC) = 0.84 and coefficient of variation (CV) = 0.43. The PT Probe had ICC = 0.81 and CV = 0.31. Impedance values at APs were not significantly less than at MPs or NPs. Impedance values at MPs were also not significantly less than NPs, although their individual p values were <0.05 in 4 of 6 cases. There was a significant trend of increasing impedance with repeated measurements with both the Prognos ($p = 0.003$) and the PT Probe ($p = 0.003$).

Conclusions: Within the reliability limits of our study methods, none of the three APs tested has lower skin impedance than at either of the nearby control points. These results are not consistent with previous studies that detected lower skin impedance at APs than nearby sites. Further study is necessary to determine whether MPs have lower skin impedance than nearby NPs. Our study suggests caution is warranted when developing, using, and interpreting results from electrodermal screening devices. Further studies are needed to clarify the clinically important and controversial hypothesis that APs are sites of lower impedance.

INTRODUCTION

Electrodermal screening, as practiced by acupuncturists and homeopathic clinicians, measures either skin impedance or conductance at acupuncture points (APs) as diagnostic aids for planning treatment strategies. Skin impedance is the skin's opposition to the flow of current. The impedance of skin is a function of both resistive (frequency independent) and capacitive (frequency dependent) elements. The practice of measuring skin impedance is based on the widely held assumption that APs are loci of decreased impedance compared to skin sites where there are no known APs. Research performed in an unblinded manner several decades ago by Niboyet et al.,[1] Nakatani,[2] and Voll[3] first

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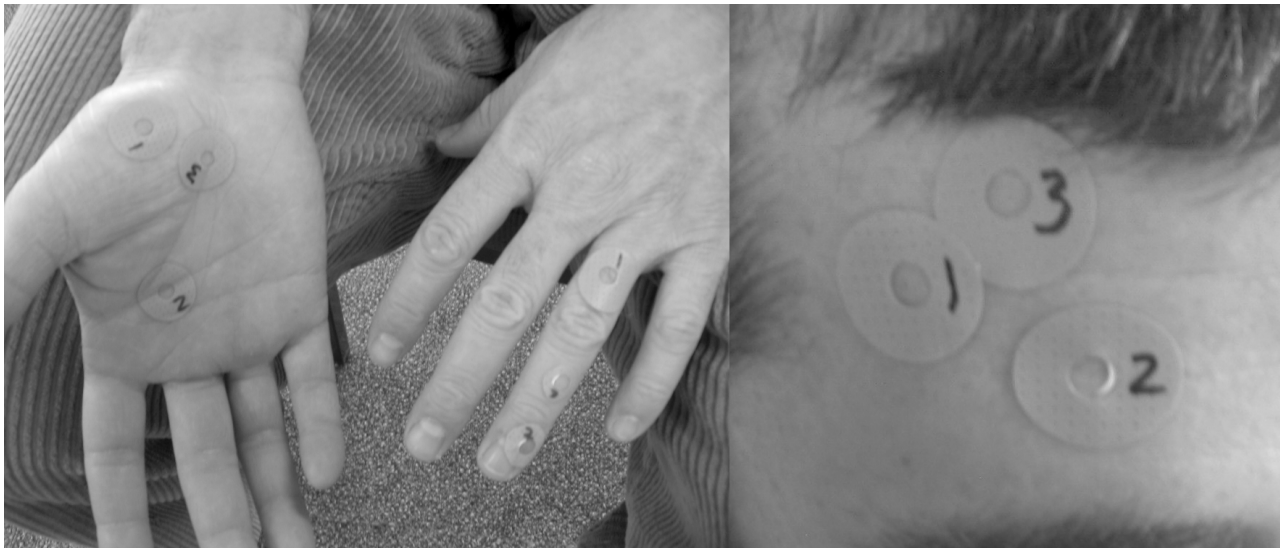

FIG. 1. Typical site locations near Pericardium (PC) 8, Triple Energizer (TE) 1, and Gallbladder (GB) 14.

demonstrated evidence of these phenomena. More recent studies, performed under stricter conditions,[4–12] confirmed these findings.

Three groups of researchers, however, using blinded evaluators and rigorous statistical analyses, concluded that, based on skin impedance measurements, APs could not be distinguished from non-AP sites.[13–15] The latter investigators point out the many possible sources of error associated with skin impedance measurements. These confounders are related primarily to the skin/electrode interface and include probe size and shape, pressure exerted by the probe, duration of probe application, inclination of the probe tip on the skin, and variations in skin condition (dry/moist, thickness and integrity of the stratum corneum). Skin impedance measurements also vary with the frequency of applied current[16,17] and with several instrumentation parameters, including whether a multichannel system,[7,9,18] a concentric probe,[8] a four-electrode system,[9,16,19] or a two-electrode system is used. Recommended AC frequency choices have included 100 Hz[17] and 200 kHz.[17,20] Impedance readings may also be influenced by fluctuations in the underlying psychophysiologic condition of the subject and potential investigator bias when an acupuncturist performs the evaluation.[15]

Skin impedance varies with the frequency at which it is measured. Rosendal proposed an electrical model for skin impedance that is commonly used.[21] Steady-state alternating current (AC) and direct current (DC) instruments are sensitive to different components of this model. For example, capacitive components only allow current to flow when the current fluctuates, as occurs with AC instruments, and is not detected by constant current (DC) instruments. High-frequency measurements (>10,000 Hz) can be sensitive to stray capacitance.

As part of a program of research exploring the properties of the *Ting* (*Jing well*) APs, we have conducted a study with Prognos (MedPrevent GmbH, Waldershof, Germany), a commercially available DC ohm meter designed for measuring skin impedance.[22] In order to compare the Prognos impedance readings with readings acquired using AC, we also designed and implemented a customized system called the PT Probe, which was designed for this study.

The purpose of this study was to assess, under blinded conditions (with constant probe pressure), whether APs are sites of lower impedance compared to non-AP sites when measured with either DC or AC devices. We chose to evaluate three classical APs: Triple Energizer 1 (TE 1), which is located at the lateral corner of the nail bed on the fourth digit of the hand; Pericardium 8 (PC 8), which is located in the palm of the hand; and Gallbladder 14 (GB 14), which located on the forehead above the eye. (Acupuncture points are signified by the Stan-

FIG. 2. Prognos (MedPrevent GmbH, Waldershof, Germany).

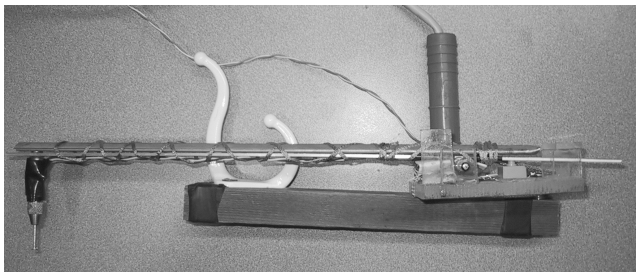

FIG. 3. PT Probe (designed for study).

dard Acupuncture Nomenclature of the World Health Organization (1993)). These APs were selected because of their distinct anatomical and topographical features and their clinical importance. We hypothesized that impedance at each of three APs would be significantly lower than two nearby (within 5 cm) control sites, which consisted of a site on the related meridian (MP) and a site off the meridian (NP). We also tested a second hypothesis that the impedance on the MP would be less than on the NP. Finally, we tested a hypothesis that repeated measurements would not affect the mean skin impedance.

METHODS

Participants and settings

Participants were recruited from the Oregon College of Oriental Medicine faculty and student body. The study was approved by the OCOM Institutional Review Board (IRB). Twenty (20) adult participants (14 females and 6 males) ages 23–65 were evaluated at OCOM after signing approved consent forms. Inclusion criteria included healthy participants with the ability to sit quietly for 30 minutes while the measurements were taken.

Selection of data points

APs are located relative to anatomical landmarks based on textbook descriptions and charts, palpation, and visual inspection. In clinical practice, APs may be palpated as areas of induration or indentation, increased warmth, and/or changes in color or sensation. Another important element of acupoint selection in clinical practice and in this study is the acupuncturist's perceived sense of the level of "energy flow" or *qi* at the acupoint. TE 1 was selected because of its location on the finger tip and because it has been used in other research studies with the Prognos.[22,23] GB 14 was selected because of its accessibility, flat anatomical feature, and common clinical usage. PC 8 was selected because of its accessibility and what our expert acupuncturists described as an "easily felt sense of *qi*." MPs were identified as points on the same meridian that were clearly not classical Chinese APs. NPs were identified as other nearby points that were not on the meridian and had substantially less "sensation of *qi*" than the corresponding APs.

Point location consensus

Four licensed acupuncturists practicing for 5 or more years were trained in advance to come to consensus about the location of the AP, MP, and NP sites. At each session, three of the acupuncturists located the sites using visual inspection, digital palpation, and "sensation of *qi*." Although there was no time limit given to the acupuncturists to come to consensus on all nine study sites on each person, the process took 10–15 minutes for each participant. Typical point locations for the sites near TE 1, PC 8, and GB 14 are shown in Figure 1.

Equipment

Prognos. The Prognos is used clinically to measure skin impedance at *Ting* (*Jing well*) acupuncture points located at the corners of the finger and toenail beds. It was found to be reliable for repeat measurements at these acupuncture points.[22,23] The Prognos uses a 4.57-mm-diameter probe tip. It averages 400 measurements taken during approximately 200 milliseconds. When triggered at a pressure of approximately 163 ± 3 kPa, Prognos applies a DC current of 1.1 μA. The Prognos is shown in Figure 2.

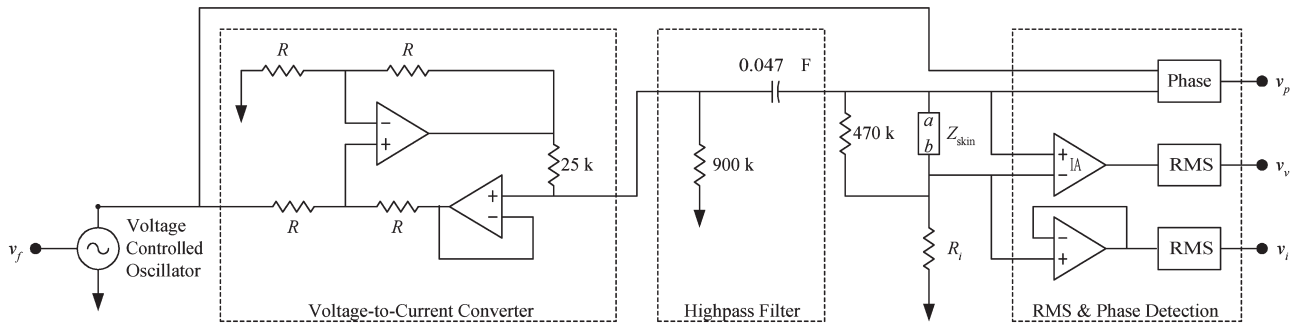

FIG. 4. Impedance circuit.

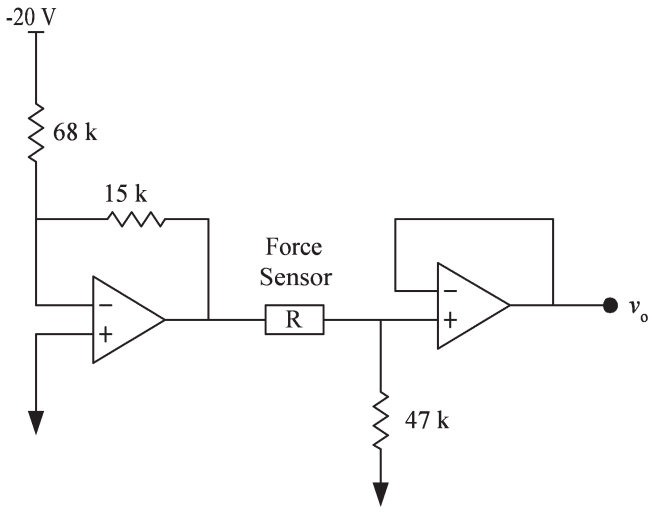

FIG. 5. Force sensor circuit.

PT Probe. The second device, which was designed and built for this study, is called the PT Probe. It consists of a probe, signal-conditioning circuitry, and a laptop-based data acquisition system. The probe was designed to trigger at approximately the same pressure as the Prognos. We used a lever design to achieve a suitable input for the pressure sensor. A metal probe tip with a diameter of 3.56 mm was used. A handle allowed the measurements to be easily taken. The PT Probe is shown in Figure 3.

We developed circuitry to measure skin impedance and convert force sensor resistance into a voltage.[24] A circuit diagram is shown in Figure 4. A 470-kΩ resistor in parallel with the skin was added and the current source was reduced to 14.2 μA to increase the measurable impedance range. Unlike the Prognos, the PT Probe applied a sinusoidal current with a frequency of 100 Hz. The voltage across the resistor–skin parallel combination was recorded by a data acquisition card onto a laptop computer. The load impedance Z_S was calculated as $Z_S = R_P / ((I_{RMS} \times R_P/V_{RMS}) - 1)$, where R_P is the value of the parallel resistor and I_{RMS} and V_{RMS} are the root-mean-squared current and voltage, respectively. The maximum current through the skin was limited to 14.2 μA, and the maximum voltage was limited to 6.8 V.

A force sensor (CUI Inc. IESP-12) was used to control the pressure at which the measurements were taken. A simple circuit shown in Figure 5 was used to convert the sensor resistance into a voltage. The circuit produced a voltage of 2.7–3.5 V when a force of 0.75–1.22 N was applied to the probe tip. This force applied over the 9.95 mm^2 area of the probe tip gives a pressure of 75–122 kPa.

The voltages were acquired with a National Instruments (Austin, TX) 6062-E DAC and stored on a laptop computer. The signals were sampled at 5 kHz and decimated to 500 Hz. The voltage was squared and lowpass filtered. The square root was then taken to obtain the root mean squared voltage. This voltage was averaged over the 2-second interval for which the pressure sensor voltage was in the 2.7–5.4 V range.

Protocol

Electrical impedance at three APs (right GB 14, right PC 8, and left TE 1) and the corresponding MPs and NPs were measured on each of the 20 participants with both devices.

Once the three acupuncturists came to consensus on the point, circular adhesives with a 5-mm-diameter central perforation were placed over each of the nine agreed-upon sites on each participant and then were coded for data collection purposes. The skin was prepared by exfoliation with tape (five times per site) and then cleansed with ethyl alcohol. Digital photographs of all of the marked sites were taken for each participant (Fig. 1).

Participants were asked to sit quietly while the measurements were obtained with both devices. The probe tips were cleansed with ethyl alcohol at the beginning of each session. The technician who acquired the measurements was not an acupuncturist. Each AP, MP, and NP was measured four times by each device in random order. Half of the partici-

TABLE 1. PROGNOS[a] AND PT PROBE[b] RELIABILITY

	Mean of medians	*Standard deviation within participants*	*Standard deviation between participants*	*ICC*
Prognos				
GB 14	2469	2039	5428	0.88 (0.82–0.92)
PC 8	5077	3093	9028	0.89 (0.85–0.93)
TE 1	10,877	7482	14,000	0.78 (0.69–0.85)
PT Probe				
GB 14	750	1108	1165	0.53 (0.40–0.65)
PC 8	5320	6412	11,214	0.75 (0.66–0.83)
TE 1	8149	5764	12,972	0.84 (0.77–0.89)

[a]MedPrevent GmbH, Waldershof, Germany.
[b]Designed for this study.
ICC, intraclass correlation; GB, Gallbladder; PC, Pericardium; TE, Triple Energizer.

Table 2. Prognos[a] Intra- and Interperson Variability

	Mean (N)	*Median*	*Range (Min–Max)*	*Standard deviation within participants*	*Standard deviation between participants*	*ICC*
GB 14						
AP	4.0	694	1864 (145–2009)	2219	7870	0.93 (0.86–0.97)
MP	4.0	333	433 (182–615)	1374	1356	0.49 (0.27–0.72)
NP	4.0	994	1616 (448–2064)	2379	4911	0.81 (0.67–0.91)
PC 8						
AP	3.6	3256	1764 (2776–4540)	2928	8384	0.89 (0.80–0.95)
MP	3.7	2928	2009 (2354–4363)	2784	8254	0.90 (0.81–0.95)
NP	3.8	2909	1778 (2337–4115)	3501	10,647	0.90 (0.82–0.96)
TE 1						
AP	3.8	6882	8588 (3663–12,251)	7351	9458	0.62 (0.41–0.81)
MP	3.8	3553	1694 (2111–3805)	4931	12,376	0.86 (0.75–0.94)
NP	3.8	12493	14535 (4820–19,355)	9496	18,064	0.78 (0.63–0.90)

[a]MedPrevent GmbH, Waldershof, Germany.

ICC, intraclass correlation; GB, Gallbladder; AP, acupuncture point; MP, on the meridian; NP, off the meridian; PC, Pericardium; TE, Triple Energizer.

pants had Prognos measurements taken first and half had the PT Probe measurements taken first. Prognos measurements were recorded into a spreadsheet by a second technician. The PT Probe measurements were automatically recorded into a custom data acquisition program. Neither technician knew the mapping between codes and sites.

Device reliability

Both the Prognos and the PT Probe were tested against a set of nine known resistors ranging from 0 to 5 MΩ before and after the recordings were taken for each day of the study. Measurements with poor electrical contact were excluded.

To determine the reliability of the devices, four repeated measurements were obtained from each of the nine sites (an AP, MP, and NP at each of the three APs) with each device from each participant for a total of 36 measurements per participant. The reliability of each device was quantified with two normalized indices: the intraclass correlation coefficient (ICC) and the coefficient of variation (CV).[25,26] An ICC close to 1 indicates that the repeated measurements produce consistent values as compared to the differences between sites and indicates that the device can reliably distinguish between sites. A small CV indicates that repeated measurements at the same site are consistent.

Statistical analysis

In some cases, the Prognos was unable to provide a measurement, so fewer than four measurements were available

Table 3. PT Probe[a] Intra- and Interperson Variability

	Mean (N)	*Median*	*Range (Min–Max)*	*Standard deviation within participants*	*Standard deviation between participants*	*ICC*
GB 14						
AP	4.0	405	372 (163–534)	928	963	0.52 (0.30–0.73)
MP	4.0	244	305 (153–459)	1328	984	0.35 (0.14–0.61)
NP	4.0	534	717 (187–903)	1028	1527	0.69 (0.50–0.84)
PC 8						
AP	4.0	2142	762 (1867–2629)	5143	15914	0.91 (0.83–0.96)
MP	4.0	2318	551 (2094–2644)	7774	10368	0.64 (0.44–0.81)
NP	4.0	2238	864 (2004–2868)	6037	5108	0.42 (0.19–0.66)
TE 1						
AP	4.0	3496	2230 (2445–4676)	6040	13672	0.84 (0.71–0.92)
MP	4.0	2465	1048 (2314–3362)	6489	16625	0.87 (0.76–0.94)
NP	4.0	3979	2280 (3016–5297)	4590	7526	0.73 (0.55–0.87)

[a]Designed for this study.

ICC, intraclass correlation; GB, Gallbladder; AP, acupuncture point; MP, on the meridian; NP, off the meridian; PC, Pericardium; TE, Triple Energizer.

Table 4. Prognos[a] Intersite Variability

	Mean of medians	*Median of medians*	*Standard deviation*	*Range (min, max)*
GB 14				
NP-AP	100	149	7944	45,461 (−24,635, 20,826)
NP-MP	2364	604	5543	27,173 (−5911, 21,262)
NP-NP	−2264	−198	7934	38,065 (−33,514, 4551)
PC 8				
NP-AP	−666	−5	3404	15,345 (−9195, 6150)
NP-MP	246	340	4015	19,311 (−12,958, 6353)
NP-NP	−572	−258	4568	24,862 (−12,337, 12,525)
TE 1				
NP-AP	5506	1802	16,111	77,033 (−23,176, 53,857)
NP-MP	6030	1920	15,831	74,114 (−28,892, 45,222)
NP-NP	−2829	−3125	12,983	50,789 (−20,082, 30,707)

[a]MedPrevent GmbH, Waldershof, Germany.
GB, Gallbladder; NP, off the meridian; AP, acupuncture point; MP, on the meridian; PC, Pericardium; TE, Triple Energizer.

for analysis. The median of the available measurements was used for the hypothesis tests.

Preliminary measurements with both devices produced significant outliers with a skewed distribution, so we used the nonparametric sign test to compare impedance at two sites. For each of the two devices and each of the three APs, we tested whether the impedance at the AP was lower than the corresponding MP, whether the impedance at the AP was lower than the corresponding NP, and whether the impedance at the MP was lower than the NP for a total of 18 comparisons (2 devices × 3 AP sites × 3 comparisons at each site). We used a modified test level of significance on the 18 impedance comparisons to obtain a family level of significance of 0.05. The level of significance of the individual test was 0.00283.

We also tested for a trend of increasing or decreasing impedance with repeated measurements from each device for a total of two additional hypothesis tests. For the trend tests, the Cox and Stuart test for trend was used to compare consecutive measurements.[27] At each unique point, the first measurement was compared with the third and the second with the fourth. If there were only three measurements, then only the first and third were compared. If there were two measurements, they were compared with each other. Our test statistic was the total number of times the later measurements were higher than earlier measurements among all of the points. The trend tests were conducted with a separate family level of significance of 0.05. The level of significance of the individual test was 0.02532.

RESULTS

The Prognos resistance measurements had an ICC = 1.00 and standard deviation of 20.5 kΩ or 1.4% of the overall

Table 5. PT Probe[a] Intersite Variability

	Mean of medians	*Median of medians*	*Standard deviation*	*Range (min, max)*
GB 14				
NP-AP	204	74	2125	12,447 (−4761, 7686)
NP-MP	290	65	1250	7050 (−2590, 4460)
NP-NP	86	18	1608	8286 (−3444, 4842)
PC 8				
NP-AP	−3317	−344	8709	40,453 (−38,612, 1841)
NP-MP	−2294	−340	12,271	56,396 (−54,938, 1458)
NP-NP	−1023	−347	4227	21,324 (−16,326, 4998)
TE 1				
NP-AP	−1098	828	17,090	81,498 (−57,716, 23,782)
NP-MP	−2397	648	12,967	71,987 (−47,586, 24,401)
NP-NP	1299	−528	19,772	106,356 (−41,994, 64,362)

[a]Designed for this study.
GB, Gallbladder; NP, off the meridian; AP, acupuncture point; MP, on the meridian; PC, Pericardium; TE, Triple Energizer.

mean. The PT Probe had an ICC = 1.00 and standard deviation of 33.2 kΩ or 2.2% of the overall mean.

The Prognos skin measurements had an intraclass correlation ICC = 0.84 and an average CV = 0.43. The PT Probe skin measurements had an ICC = 0.81 and an average CV = 0.31. Table 1 lists reliability statistics for the two devices. Tables 2 and 3 show inter- and intraperson variability. Tables 4 and 5 show intersite variability. For these tables, the median of the four measurements at one site for each person was subtracted from that of a neighboring site. All impedance values are listed in units of kΩ.

Tables 6–8 list the hypothesis test *p* values. In some participants, we were unable to obtain readings from the Prognos because these readings were out of the range of the instrument. Because of this, the average number of measurements is reported in Tables 2 and 3, and numbers of valid pairs for comparison are reported for the Prognos in Tables 6–8. Tables 9 and 10 list the median impedance at each point measured for each device. A value of NA indicates that we were unable to obtain any measurements for that point.

Skin impedance at APs was not significantly less than at MPs, skin impedance at APs was not significantly less than at NPs, and skin impedance at MPs was not significantly less than at NPs at any of the three APs measured with either device.

There was a significant trend of increasing impedance in the repeated measurements from both Prognos ($p = 0.003$, N = 344) and the PT Probe ($p = 0.003$, N = 360). On average, the impedance increased by 0.62% or 778 Ω for Prognos, and 4.62% or 442 Ω for the PT Probe.

DISCUSSION

Comparisons of skin impedance measurements recorded at different APs and non-AP control sites, using different measuring instruments and techniques is complex. When we measured three classical APs using a two-electrode DC device and a two-electrode AC device, and compared the impedance measurements to those taken at each of two nearby control sites (MPs and NPs), the skin impedance at APs was not statistically different than at the control sites. However, several of the hypothesis tests had *p* values <0.05. In particular, the trend tests and the tests for MP having lower impedance than NP had low *p* values (<0.05) in four of six cases. The test results taken collectively are not significant at the 5% family level of significance, but suggest that lowered skin impedance at MPs warrants further study.

Table 6. GB 14 Hypothesis Test Results (*p* Values)

Test	*N (Prognos*[a]*)*	*Prognos*[a]	*PT Probe*[b]
AP<MP	20	0.4119	0.1316
AP<NP	20	0.1316	0.0207
MP<NP	20	0.0059	0.0059

[a]MedPrevent GmbH, Waldershof, Germany.
[b]Designed for this study.
AP, acupuncture point; MP, on the meridian; NP, off the meridian.

Table 7. PC 8 Hypothesis Test Results (*p* Values)

Test	*N (Prognos*[a]*)*	*Prognos*[a]	*PT Probe*[b]
AP<MP	18	0.9519	0.9423
AP<NP	18	0.4073	0.7483
MP<NP	19	0.0318	0.5881

[a]MedPrevent GmbH, Waldershof, Germany.
[b]Designed for this study.
AP, acupuncture point; MP, on the meridian; NP, off the meridian.

A number of factors may potentially explain the lack of differences in impedance observed between APs, MPs, and NPs. It is possible that indeed, no differences exist or that differences if they do exist appear only during ill health. There may also be some methodological explanations for the lack of differences we found. Our negative findings are in accord with three groups of investigators who demonstrated that the many well-known confounders in impedance measurements preclude a differentiation of APs from surrounding areas.[13–15] Our results, however, are inconsistent with those of several groups who found significantly lower skin impedance at APs than at non-AP sites using different methods and a variety of instruments.[4,6–11,16,18,20,28–30]

Proximity of AP to non-AP site and probe tip size

Researchers who used 36- or 256-channel probes (individual probe tip size 1–2-mm diameter) positioned over the site of a classical AP detected loci of significantly lower impedance in relation to the immediate surrounding area (within 2–4 mm^2) of the center of the site of lowest impedance.[6,7,9,28] The probes used in our study were substantially larger (4.5 mm and 3.5 mm in diameter) and skin sites with which comparisons were made were up to 5 cm away. Jakoubek and Rohlicek found that a central point of low impedance coinciding with the site of classical APs was 350 μm in diameter in rats and 450 μm in humans.[7] If we had used a smaller probe tip (1–2 mm) and measured sites that were less than 3 mm apart, we might have been able to identify these very small loci of relative decreased impedance.

Skin condition at selected sites

Hyvarinen and Karlsson[8] used a concentric probe with a central electrode surrounded by a ring that allowed com-

Table 8. TE 1 Hypothesis Test Results (*p* Values)

Test	*N (Prognos*[a]*)*	*Prognos*[a]	*PT Probe*[b]
AP<MP	18	0.9519	0.9423
AP<NP	18	0.1189	0.1316
MP<NP	19	0.0481	0.0577

[a]MedPrevent GmbH, Waldershof, Germany.
[b]Designed for this study.
AP, acupuncture point; MP, on the meridian; NP, off the meridian.

parison of impedance at points 2.5 mm from the center. They systematically recorded measurements over the entire hand and ear, moving in 1-mm steps, and found distinctive low-resistance points that coincided with classical APs on the ear and on the dorsum of the hand, but no distinctive points on the palmar surface of the hand except at the interphalangeal joints. In retrospect, our choices of PC 8 and its associated NP and MP (on the palm) were not the best for defining a clear-cut difference between AP and non-AP sites because even imperceptible palmar sweating may equalize skin impedance over the entire palm.

APs on the legs, arms, and back were not chosen because preliminary work indicated that the Prognos was unreliable for measuring those sites. Ear APs were not chosen because our probe tips were too large, and when Margolin et al.[31] assessed the reliability of ESR at ear APs for use in clinical trials, they found that active zones in the ear had overall lower impedance, but the measurements at specific points could not be obtained with sufficient accuracy.

Possible inaccurate AP and non-AP point location

Three experienced acupuncturists, using their knowledge of classical acupuncture charts, anatomical landmarks, palpatory skills, and other sensory cues, came to consensus on locations for the APs and non-APs. All acknowledged that it was more difficult finding a "non-AP" site, which is not part of their usual clinical practice. Despite this difficulty, no sites were chosen without full consensus of the group, so it is unlikely that the points were chosen in error.

Inadequacy of measuring devices for points tested

The Prognos device was shown to be reliable for measuring the *Ting* (*Jing well*) points, located over bone, at the finger and toenail beds. This device, however, had not been tested for reliability in measuring either sites more proximally located on the finger or sites on the forehead or on the palmar surface of the hand. We found that more fleshy areas were not firm enough to deflect the Prognos' probe tip before the outer shell came into contact with the skin, thus increasing the measurement pressure, which might contribute to erroneous measurements.

We found that the impedance of the skin increased significantly with repeated measurements with both the Prog-

Table 9. Prognos[a] Median Impedances (kΩ)

	GB 14			*PC 8*			*TE 1*		
Subject	*AP*	*MP*	*NP*	*AP*	*MP*	*NP*	*AP*	*MP*	*NP*
1	19	1323	8072	3171	2928	3242	3032	33,739	4847
2	4657	175	706	3133	15,658	2701	6882	NA	60,739
3	620	129	2046	2568	2331	2882	4604	2000	1607
4	258	3408	669	860	569	1247	4378	733	451
5	2521	7072	1161	2843	2569	2909	1419	2376	2762
6	1471	973	269	5522	3751	5446	33,301	18,632	10,125
7	731	1167	503	3341	4081	9491	26,312	11,905	20,180
8	10,339	740	7013	7555	7369	3612	1808	9859	4038
9	57	151	827	5485	1035	1349	2552	4797	810
10	868	299	588	2674	2112	5315	9290	1720	17,392
11	46	57	107	1817	3294	3735	1491	1405	3281
12	5332	56	374	NA	NA	NA	15,789	4120	15,302
13	62	151	151	39,957	27,620	30,762	18,038	39,641	41,604
14	33,964	450	9329	NA	34,608	40,961	NA	37,371	59,136
15	658	252	1734	1025	1828	1841	22,300	2218	47,440
16	803	367	21,628	3879	3872	6849	12,395	3553	14,213
17	105	1065	5390	5309	1479	1400	2283	387	1006
18	1185	387	3332	4107	2204	1393	11,826	2446	NA.
19	75	165	1669	1871	3756	1521	21,822	4037	31,361
20	27	142	237	3704	2066	1143	2854	1014	12,493

[a]MedPrevent GmbH, Waldershof, Germany.
GB, Gallbladder; PC, Pericardium; TE, Triple Energizer; AP, acupuncture point; MP, on the meridian; NP, off the meridian.

Table 10. PT Probe[a] Median Impedances (kΩ)

	GB 14			*PC 8*			*TE 1*		
Subject	*AP*	*MP*	*NP*	*AP*	*MP*	*NP*	*AP*	*MP*	*NP*
1	93	139	239	2862	2432	1167	2193	5179	2039
2	574	167	243	5911	10,909	4613	3506	67,868	10,153
3	237	327	598	1869	1190	2440	6746	1564	1131
4	796	2000	473	2020	1254	3094	5508	1936	2419
5	604	5446	685	2477	2029	2591	3486	2938	3220
6	786	284	324	10,019	2487	3387	66,283	24,289	18,697
7	133	597	596	1932	2430	3390	7308	6092	3949
8	716	238	1662	2158	1607	1261	6065	41,423	3172
9	98	163	217	1927	866	524	553	1638	796
10	736	205	234	2104	1951	1977	1051	1391	2306
11	107	115	113	1309	2760	2037	1059	895	1635
12	730	111	183	66,607	50,282	11,669	14,606	15,225	39,007
13	131	157	138	3547	3415	3023	921	762	5305
14	3574	130	984	18,357	18,237	17,308	19,196	4746	6939
15	591	249	625	969	1511	1638	3100	2556	4010
16	3813	587	8273	2087	2581	2850	2923	2466	4619
17	128	655	1068	1585	1322	1687	1422	909	2142
18	123	334	764	2794	1322	948	6957	1862	15,275
19	134	477	718	2126	4084	1970	6588	2464	7967
20	111	120	159	2673	2205	1430	2176	1422	4911

[a]Designed for this study.
GB, Gallbladder; PC, Pericardium; TE, Triple Energizer; AP, acupuncture point; MP, on the meridian; NP, off the meridian.

nos and the PT probe devices. This agrees with Noordergraaf and Silage,[15] who found that the impedance increases to a plateau dependent on probe size, inclination, skin dryness, and proximity of underlying bone structure. Another possible explanation is that, after cleansing the probe tips with ethyl alcohol at the beginning of each session, the probe tips acquired a layer of debris with subsequent measurements that increased the impedance. Because all of these factors were approximately constant for each location we tested, and the measurement order was randomized, this had no effect on our statistical analysis.

CONCLUSIONS

Within the reliability limits of our instrumentation and the research design, none of the APs tested had statistically lower skin impedance than nearby control points. These results are not consistent with earlier studies that detected lower skin impedance at APs. Further study is warranted to determine whether MPs have lower skin impedance than nearby NPs. Our study suggests that caution is warranted when developing, using, and interpreting results from electrodermal screening devices. Further studies are needed to clarify the clinically important and controversial hypothesis that APs are sites of lower impedance.

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