Clinical utility of electrodermal activity at acupuncture points: a narrative review

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Abstract

Objectives To provide an in-depth analysis of seven well-reported studies that examined electrodermal activity (EDA) at acupuncture points with regard to three commonly held tenets of acupuncture: (1) EDA at pathology-related acupuncture points is distinguishable from non-pathology-related acupuncture points; (2) EDA at acupuncture points can assist in diagnosing and monitoring therapeutic progress; and (3) EDA at acupuncture points is able to identify substances that are either therapeutically beneficial or toxic to an individual.

Methods Seven of 29 studies that scored >50% on their quality of reporting 54 essential technical and clinical details of EDA testing in human patients were identified from a previous literature review. Fourteen categories of data were extracted from these seven studies for further discussion.

Results Two studies compared EDA at pathology-related auricular acupuncture points to non-pathology-related sites. Two studies correlated EDA measurements at sites other than auricular acupuncture points with the presence of specific medical conditions. The final three studies assessed changes in EDA at acupuncture points on the fingers and toes when different substances were placed in the electrical circuit with the patient.

Conclusions This review highlights the heterogeneity of approaches to EDA assessments and the discrepancies between common clinical practice and the scientific evidence to support that practice. It also provides pilot data that suggest EDA testing at auricular acupuncture points may distinguish pathology-related acupuncture points from non-pathology-related points; decreased skin conductance correlates with tiredness or low energy; and EDA testing at the Jing-Well acupuncture points, on the tips of the fingers and toes, may assist in monitoring effectiveness of acupuncture treatment. The evidence does not support the use of VEGA testing for allergic status.

INTRODUCTION

Four commonly held tenets among acupuncturists regarding electrodermal activity (EDA) at acupuncture points are: (1) acupuncture points have lower electrical resistance than surrounding skin[1–4]; (2) pathology-related acupuncture points are distinguishable from non-pathology-related acupuncture points[5]; (3) changes in electrical skin resistance or conductance at acupuncture points correlate with acupuncture treatments and with the persistence of, or recovery from, disease[6]; and (4) changes in EDA at acupuncture points occur when substances that are either therapeutically beneficial or toxic to an individual are placed in the electrical circuit with that individual.[7 8] For more than 50 years these widely-held assumptions have formed the basis for the use of electrodermal devices in clinical practice, yet scientific studies to support these beliefs are sparse and methodologically diverse. The first tenet was comprehensively evaluated by Ahn *et al*[9] in a recent systematic review. This review found preliminary evidence to suggest that acupuncture points and meridians may be electrically distinguishable from non-acupuncture point and non-meridian tissue. The latter three tenets, however, have yet to be rigorously examined.

We recently critiqued the quality of reporting technical and clinical details in 29 studies of EDA at acupuncture points in human patients.[10] Seven of the 29 studies that scored >50% in quality of reporting were selected for an in-depth analysis and further discussion in this narrative review. The objectives of this review are to summarise and appraise data supporting or challenging the clinical use of EDA testing at acupuncture points and to call attention to the heterogeneity of EDA testing approaches. We will detail the study methodology, assess the quality of the data, interpret the utility of EDA testing within clinical practice and highlight findings that we believe warrant further investigation.

MATERIALS AND METHODS

Literature review

Complete details of the literature review of 29 original studies with inclusion/exclusion criteria and data extraction processes are provided in Colbert *et al*.[10]

Study quality and scoring criteria

For the previous review we extracted and scored data on 54 items that needed to be reported if a study was to be replicated. The 54 items were grouped into 10 equally-weighted

broad categories (general aspects of study, subjects/settings, skin site selection, controls, electrodes, confounding variables, instrument/electrical parameters, measurements, blinding, results). A Quality Assessment Score was developed to quantify how completely each item in the 10 categories was reported. Two points were given if an item was described in enough detail to characterise the clinical aspects and electrical parameters. One point was given if the item was only partially described but enough detail was given to make reasonable inferences about that item. For example, if the Electroacupuncture according to Voll (EAV) method was named we assumed, although not clearly stated, that a direct current (DC) rather than an alternating current was applied to obtain electrical conductance measurements. In this case, one point was given for the item that requested 'Type of current and rationale'. One point was also given if, for example, the authors did not specifically state that control skin sites were assessed under the same conditions as active sites but described testing several sites that included both active and control points in one measurement session. Zero points were assigned if an essential informational item was not mentioned in the report. A perfect Quality Assessment Score was 100% for the 10 categories. Nine of the original 29 studies scored >50% on quality of reporting essential technical information. Of these nine better reported studies, seven[11–17] provided sufficient clinical detail to permit study replication and a critical assessment of results.

Data synthesis and analysis

Data were extracted from the seven studies on the 14 categories of information listed in box 1 and the studies were categorised according to the three commonly held assumptions regarding EDA utility—that is, pathology-related acupuncture point versus non-pathology-related point; EDA correlation with clinical condition; and EDA changes when substances are placed in the patient/instrument electrical circuit.

Overall summary

Two studies were performed at ear points,[11 12] one was a limb to limb comparison,[13] one measured Jing-Well points at the finger and toe nailbeds[14] and three entailed EAV measurements.[15–17] Two of the seven studies compared EDA at pathology-related acupuncture points with EDA at nearby non-pathology-related sites.[11 12] Two other studies correlated EDA measurements with the presence of, persistence of, or recovery from specific medical conditions.[13 14] One study correlated skin conductance between the four limbs in patients with an acupuncture diagnosis of 'Qi vacuity' (tiredness/low energy).[13] Another evaluated skin impedance at the Jing-Well acupuncture points in young women with laparoscopically-confirmed endometriosis who were treated with verum or sham acupuncture.[14] The final three studies assessed whether changes in skin conductance at acupuncture points occurred when small amounts of substances were placed in the electrical circuit with the patient.[15–17] The latter three studies all used the EAV approach.

Detailed analysis of each study in accordance with the tested acupuncture tenet

The specific clinical and electrical details of each study are described in tables 1 and 2, respectively.

Is electrical skin resistance or conductance at pathology-related acupuncture points different from non-pathology-related acupuncture points?

The objective of the study by Oleson *et al*[11] was to scientifically validate the somatotopic pattern of reflex points on the auricle by determining the concordance between auricular electrodermal representation of pain and the actual location of musculoskeletal pain. The researchers assessed electrical conductivity at 12 ear acupuncture points in 40 patients. Measurements were recorded twice at each point on each ear. The operator categorised the auricular point as 'reactive' if the point was both tender and associated with a current reading >50 μA. A χ^2 test determined concordance of auricular diagnosis with medical history diagnosis. The mean current at ear acupuncture points associated with a pain problem was 60.3 μA compared with 38.6 μA at ear acupuncture points not associated with a pain problem. Combining the number of 'reactive' 'problem present' ear points with 'non-reactive' 'problem absent' ear points yielded an overall correct identification rate of 75.2% with 12.9% false positives and 11.9% false negatives. Abnormal conductivity was present in both ears, but the current intensity at the ipsilateral ear was greater than at the contralateral ear. This study is limited by small sample size, lack of details about participant recruitment and individuals' health status, lack of discrimination between recent and past musculoskeletal pain and the simple statistical analysis employed.

The second study conducted by Margolin *et al*[12] tested the hypothesis that electrical resistance at the auricular acupuncture points typically needled as part of the National Acupuncture Detoxification Association (NADA) protocol for drug-abusing patients differs from non-treatment zones on the ear. Four treatment zones were compared with four control zones in 34 methadone-maintained patients. A fixed amount of gel, used to minimise the confounding factor(s) of pressure and variations in contact resistance, was applied

Box 1 Data extracted from seven well-reported studies[11–17]

- Acupuncture tenet examined
- Medical condition
- Research question/hypothesis/objectives
- Electrodermal activity evaluation approach
- Number of participants
- Acupuncture points measured
- Controls (substances, skin sites, persons)
- Blinding
- Electrical measurements and instrument
- Number and order of electrical measurements
- Outcome measures
- Statistical analyses
- Results
- Conclusions

Table 1 Clinical details of seven well-reported studies

Reference	QA score	Medical condition	Number of participants	Blinding	Controls	Acupuncture points
Is electrodermal activity at pathology-related acupuncture points different from non-pathology-related acupuncture points?						
Oleson *et al* [11]	55%	Musculoskeletal pain	20 patient volunteers from Pain Management Clinic and Student Health Services aged 18–66 years (mean 34 years)	Physician blinded to patient condition	20 participants who lacked established medical diagnosis involving body part related to auricular acupuncture point	12 acupuncture points on each ear (foot/toes, lower leg/ankle, upper leg/knee, hip/buttocks, lower back, upper back, neck, head, hand/fingers, wrist, lower arm and elbow, upper arm/ shoulder)
Margolin *et al*[12]	75%	History of cocaine abuse	34 methadone-maintained patients, average duration of opiate use 13.3 years, mean age 36.7 years	No blinding	Four 'control' zones on helix of ear not typically needled for substance abuse	Four auricular zones (9–16 mm^2) in the concha of ear (Shenmen, Sympathetic, Liver, Lung)
Do changes in electrodermal activity at acupuncture points correlate with the presence of and/or recovery from disease?						
Yu *et al*[13]	57%	Acupuncture diagnosis: Qi vacuity/tiredness	103 tired patients (53 men, 50 women, age 24–76)	No blinding	143 healthy volunteers (64 women, 69 men, age 22–78)	No specific acupuncture points- measured the balance of skin conductance among four limbs
Ahn *et al*[14]	54%	Laparoscopically-confirmed endometriosis	14 women with endometriosis (aged 14–22) enrolled in acupuncture trial, nine received verum acupuncture	No blinding of EDA operator	Five study participants who received sham acupuncture	24 Jing-Well points on toes and fingers
Can changes in electrodermal activity be detected at acupuncture points when substances that are either therapeutically beneficial or toxic are placed in the electrical circuit with an individual?						
Krop *et al*[15]	51%	Polysymptomatic allergic patients	41 patients with 11 medical diagnoses	Operator blinded to contents of test vials	Normal saline, distilled water	First connective tissue point on medial side of third toe
Lewith *et al*[16]	54%	Previous positive skin prick test to dust mite or cat dander	15 skin prick-positive patients	Operator and participant blinded	Distilled water 15 skin prick- negative volunteers	Terminal acupuncture point on lateral side of third toe (spleen/ pancreas meridian)
Semizzi *et al*[17]	66%	Allergic rhinitis and/or asthma	72 allergic patients	Operator, assistant and participant all blinded	Normal saline 28 healthy volunteers	Lateral side of fifth finger

EDA, electrodermal activity; QA, Quality Assessment Score.

via a syringe between the skin and the test probe. Four measurements were recorded in each of the eight skin sites and an overall mean score was calculated for all active and control zones. Active zones had significantly lower electrical resistance than control zones. Limitations of this study include small sample size, no details about comorbid conditions in the participants, lack of comparison with healthy or non-addicted control volunteers, lack of blinding and lack of generalisability to patients with other conditions.

Conclusions

Evidence from these two well-conducted auricular studies suggests that, in patients with past or present musculoskeletal pain conditions, increased skin conductance is present at pathology-related auricular acupuncture points but not at non-pathology-related points. That such a correlation was found is a remarkable validation of the homuncular map originally identified by the French acupuncturist Nogier.[18] The conclusions of these investigators are strengthened by their comparison with results in volunteers who lacked an established medical diagnosis involving the same body parts.

In the study by Margolin *et al*,[12] however, we cannot draw the same inference as a non-addicted comparison group was not tested. Although it is generally assumed among clinicians that NADA acupuncture points are related to the pathology of substance abuse, it is possible that non-abusers may also have lower electrical resistance at the NADA points compared with control zones on the auricular helix. Nevertheless, based on these two studies, further investigation of auricular acupuncture points in patients with dysfunction in specific anatomical areas of the body is clearly warranted.

Do changes in electrical skin resistance or conductance at acupuncture points correlate with the presence of and/or recovery from disease?

Yu *et al*[13] examined the relationship between Qi vacuity, an acupuncture diagnosis that corresponds with patient complaints of tiredness and low energy, and skin conductance. They used a four-quadrant EAV testing method which entails recording electrical conductance between both feet, both hands, between the right hand and left foot and between the left hand and right foot.[7] Measurements

Table 2 Electrical and technical details of seven well-reported studies

Reference	Electrical instrument and measurement parameters	Probe	Frequency of measures
Oleson *et al*[11]	Constant voltage system, 9 V DC, measures conductance	1.5 mm spring-loaded dry probe application, hand-held metal bar reference electrode	One test session
Margolin *et al*[12]	Custom designed constant current system, 2.5 μA biphasic square pulses, 5 Hz, measures resistance	1 mm diameter probe with gel, 0.79 cm^2 reference electrode	One test session
Yu *et al*[13]	VGH-82A, constant voltage 1.75 V, measures conductance, values are normalised on 0–200 scale	Feet placed on metal plates, hands grasp metal cylinders. Conductance measured between limbs	One test session
Ahn *et al*[14]	Hibiki-7 impedance, biphasic voltage spikes, peak-to-peak magnitudes (100 V), pulse width 400 μs, 12–20 Hz. Normalised current (0–100 μA)	Metal cylinder held by subject, 2 mm metallic probe tip placed on acupuncture point by the practitioner	16 test sessions over 8 weeks
Krop *et al*[15]	Vega II measures potential difference between Honeycomb H and acupuncture point	Measuring stylus applied by operator to skin sites. Reference is hand-held silver electrode	Two independent trials by same technicians on different days
Lewith *et al*[16]	Vegatest protocol, 'Vega probe' on terminal acupuncture point, skin resistance measured when new glass ampoule with experimental substance placed in honeycomb, instrument calibrated between measurements	Measuring stylus applied by operator to skin sites. Reference is hand-held silver electrode	One test session
Semizzi *et al*[17]	Readings on 0–100 scale, instrument calibrated before subject measured	DBE204 silver plate electrode cylinder (~50 cm^2) held by subject (contact area 10 mm),^{2} stylus applied to acupuncture point, pressure 100–150 g, delivers 8–11μA×1 s	One test session

DC, direct current.

were made in patients who met the diagnostic criteria for Qi vacuity established by the Professional Committee for Study of Qi Vacuity Pattern.[13] To meet this diagnosis, patients must have at least three of the following signs and symptoms: fatigued spirit with decreased energy, shortness of breath on speaking, spontaneous sweating, enlarged tongue with dental impressions and an empty weak pulse. The severity of Qi vacuity was quantified by scoring each sign or symptom on a scale of 0–4 and summing the scores for each person. The Student t test was used to analyse EDA differences between healthy control participants and patients with Qi vacuity. Skin conductance in patients with tiredness was lower than in healthy age-matched controls (p=0.000) and lower skin conductance correlated positively with the Qi vacuity score (r coefficient=0.68, p=0.000). Skin conductance in the severely tired group was significantly lower than in the mild and moderately tired groups, suggesting that lower skin conductance may be closely related to the severity of Qi vacuity. This study is particularly important because, rather than correlating EDA findings with a Western medical diagnosis, it correlated EDA measurements with an acupuncture diagnosis, the purpose for which EDA testing was originally intended. Limitations of this study are that a large percentage of the patients had comorbid conditions including diabetes and chronic hepatitis, there was no blinding of EDA instrument operator or participants, no interoperator reliability testing and no description of skin preparation prior to measurements.

A study by Ahn *et al*[14] investigated whether electrodermal measures at the Jing-Well acupuncture points were associated with clinical measures in patients with laparoscopically-confirmed endometriosis. Measuring skin conductance at the Jing-Well acupuncture points on the fingers and toes evolved from the akabane technique in which the Jing-Well acupuncture points are tested for heat sensitivity.[19] Less heat sensitivity corresponds to greater skin resistance at the acupuncture point. Fourteen women with endometriosis who were participating in a sham-controlled acupuncture trial underwent twice weekly EDA measurements at the 24 Jing-Well acupuncture points over the course of the 8-week intervention. Statistical analysis evaluated the pattern of balance and symmetry (left/right, top/bottom, Yin/Yang) among the 12 paired acupuncture points and clinical outcomes. SD and Gini coefficient were used to assess statistical dispersion and asymmetry among the 12 paired meridians. Participants who received verum acupuncture had on average a substantial decrease in dispersion and asymmetry compared with the sham-treated group. At baseline, endometriosis patients had elevated impedance at the LR, SP and KI Jing-Well acupuncture points. Abnormal values decreased over time and increased balance in EDA measures corresponded with clinical improvement. The authors concluded that electrodermal measures may be significantly associated with clinical outcomes and acupuncture treatments in adolescent girls with chronic pelvic pain. Limitations of this study include a small sample size, inability to generalise findings to other EDA instruments or to other patient groups, lack of blinding in the acupuncturists and lack of prior inter- and intraoperator instrument reliability testing.

Conclusions

Preliminary evidence from these two studies suggests that skin conductance measurements should be further investigated as a means of quantifying symptom severity and monitoring treatment effectiveness.

Can changes in EDA be detected at acupuncture points when substances that are either therapeutically beneficial or toxic to an individual are placed in the electrical circuit with that individual?

The final three studies assessed whether EDA testing could correctly identify allergic patients and/or the allergen to which a person was allergic, by testing a variety of allergens in electrical circuit continuity with the patient.[15–17] All three studies used the VEGA test method developed by Schimmel[20] as an adaptation of EAV. A brief description of VEGA testing is provided by Tsuei[8] and Jeremic and Leung.[9] During testing a piezoelectric spark generator (producing 400 V/s) is initially applied to the patient. The patient holds a reference electrode and a control measurement is made by applying a stylus to points on the patient's finger or toe. The machine is adjusted until a reading of 80–100 scale units is produced. Various extracts are then sequentially placed in the circuit and the measurement repeated. A fall of ≥15 scale units is considered a positive result. The various extracts (homoeopathic doses) in sealed vials are inserted into a metal honeycomb where current flows around the vials. When a vial containing the homeopathic resonance of something allergic or toxic to an individual is placed in the circuit, VEGA testing purportedly records an increase in skin resistance. Conversely, when appropriate treatments are placed within the circuit, skin resistance reportedly normalises.

Although all three studies employed basic principles of VEGA testing, as shown in table 1, different patient samples, different allergens and control substances and different acupuncture points were evaluated. Only one study, the least rigorous of the three,[15] reported correct patient discrimination of allergens from non-allergens in 82% of the first group and 96% of the second group of subjects tested. Their measure of discrimination was the percentage of subjects who showed a positive response to mites or histamine as distinct from distilled water or saline. The other two studies concluded that EDA testing could not be used to diagnose environmental allergies[16] or correctly detect respiratory allergy.[17] However, it should be noted that, in the latter study, Semizzi *et al*[17] observed a significant drop in skin electrical response between two sequential measurements recorded in the allergic group but not in the healthy control group and interpreted this change as somehow associated with pathological status.

DISCUSSION

The analysis conducted here represents a first attempt to test three commonly-held assumptions among acupuncturists and practitioners of homeopathy regarding the usefulness of EDA at acupuncture points. Adequately reported studies that assess the clinical usefulness of EDA measurements at acupuncture points are few and markedly diverse with regard to the medical conditions assessed, the technical and clinical approaches implemented and outcomes and statistical analyses. Our findings, based on limited available pilot data, suggest that EDA testing at auricular acupuncture points may be able to distinguish auricular pathology-related acupuncture points from non-pathology-related points in patients with musculoskeletal disorders; that EDA four-quadrant testing correlates with the acupuncture diagnosis of Qi vacuity and severity of tiredness; and that skin impedance measurements at Jing-Well acupuncture points may be a useful objective outcome for monitoring effectiveness of acupuncture treatment in patients with endometriosis. More controversial are findings to support the diagnostic accuracy of VEGA testing in allergic patients.

This review is limited by both the number and quality of the existing data, particularly the lack of operator blinding in three of the seven studies. As a research topic, the clinical utility of EDA measurements at acupuncture points has not been widely investigated and the quality of reporting in published studies is generally poor.[10] Furthermore, the large variability in clinical conditions, electrodermal devices and electrical parameters, choice of acupuncture points, point locations and criteria for disease has made the establishment of any conclusive assessment about EDA nearly impossible. Nevertheless, this review has a number of salient points worth highlighting.

First, the discrepancy between the relatively widespread use of EDA in clinical settings and the existing research to justify it is noteworthy. EDA measurements recorded in clinical practice are intended to serve as a surrogate means of diagnosing Qi activity in specific acupuncture meridians based on Chinese medicine diagnoses, theory and principles, yet the majority of EDA research has evaluated EDA findings with reference to Western medical rather than acupuncture diagnoses. Although this incongruity may mitigate the interpretation of the results, manufacturers' claims regarding the clinical utility of EDA devices are not borne out by this narrative review. This does not discount the existence (or the relevance) of extensive anecdotal evidence, but rather points to the relative absence of supporting data within the realm of objective peer-reviewed literature.

Second, this review underscores the wide-ranging proposed uses for EDA. Electrodermal devices are used in clinical practice for diagnosing and also for evaluating treatment progress and assisting in treatment selection. The use of EDA testing for treatment selection goes beyond the notion that acupuncture points are passive windows which reveal the homeostatic condition of the body or that EDA testing is able to identify Qi deficiency or excess. Rather, it reflects beliefs held by many acupuncturists, homeopaths and kinesthesiologists that acupuncture points are interactive, dynamic, responsive skin sites, capable of intelligently communicating which specific substances may bolster or undermine an individual patient's health. This broader electrophysiological assessment of acupuncture points counters much of our conventional understanding of human physiology and raises multilayered questions regarding the mechanisms by which acupuncture point- and meridian-based treatments achieve therapeutic effects. A biologically plausible explanation for this self-healing intelligent process needs to be identified before widespread acceptance of these concepts is achieved.

Summary points

- Electrodermal activity of acupuncture points is used in diagnosis
- We reviewed seven good quality studies
- Some preliminary evidence justifies more research
- The evidence does not support its use in diagnosis of allergy

Finally, this review highlights the challenges and difficulties in performing EDA studies. For instance, no two studies within this review shared common acupuncture points or diagnoses. Furthermore, the variations in electrical stimuli (constant vs pulsatile, voltage vs current, etc), outcome measures (voltage drop vs instantaneous conductance, normalised or absolute, etc) and criteria for disease (eg, >50 μA or 60 μA) alone present a whole array of possibilities and impart to the future researcher the unenviable task of defending why a particular set of conditions was chosen. Out of 29 eligible studies, 22 were excluded from this review, not necessarily because the studies themselves were of poor quality but because there was simply not enough information in the published papers for an informed assessment of their quality.[10]

CONCLUSION

There is a discrepancy between the widespread use of EDA testing at acupuncture points and scientific support for the practice. Evidence from this review of pilot studies is limited and diverse, but does suggest that EDA testing at auricular acupuncture points in patients with musculoskeletal disorders may distinguish pathology-related acupuncture points from non-pathology-related points; that skin conductance testing can confirm and quantify the severity of Qi vacuity (tiredness); and that EDA testing at the Jing-Well acupuncture points should be further evaluated as an objective outcome for monitoring the effectiveness of acupuncture treatment in patients with endometriosis. The evidence available at this time does not support the use of VEGA testing for allergic status in patients, but investigation of subtle differences in EDA at acupuncture points between allergic and non-allergic patients may be justified.

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