Research report

Quantitative analysis of Electrical Skin Conductance in diagnosis: Historical and current views of Bioelectric Medicine

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ABSTRACT

The history and scientific basis for using electrical skin conductance measurements for diagnostic purposes are presented through new unpublished analyses of past and current scientific data. Skin conductances vary at acupuncture/conductance points by two to six fold compared to adjacent skin points. Primary data presented here indicate that early stages of cancer, chronic viral infection (Epstein Barr and human immunodeficiency virus), and chronic inflammatory diseases are characterized by hyper-conductances at skin points associated with lymphatics, joints, and connective tissue compared to the same points in controls. In contrast, terminal stages of cancer and AIDS are characterized by lower than normal electrical conductances, especially at the spleen points. Given reliable electrodermal screening instruments, early diagnosis of several significant disease states via measurable changes in electrical conductances may be possible, making it possible to provide early and more effective natural treatment.

INTRODUCTION

Bioelectromagnetic medicine (BEM) is an emerging science which studies the interactions between electromagnetic fields and the electrical properties of biological tissues and cells (1,2,3,4). Electromagnetic fields induce selective electrical changes in the micro-environment around and within cells (5). Numerous observations ranging from the cellular-molecular to the organismal levels explain how electromagnetic fields interact with living systems. At the cellular level, a direct relationship exists between the electrical potential of the cell membrane and signal transduction with consequential gene expression (1,6,7,8). Experiments in vitro have demonstrated quantitatively that electromagnetic devices have therapeutic effects on immune and nervous system cells, including lymphocytes, natural killer cells, leukocytes, and neurons (2,9,10,11,12,13). For example, magnetic-field exposure to thymocytes enhanced signal transduction processes via calcium second messengers (14,15). Minute exposures of direct current to cultured neuronal cells evoked nearly equivalent protein synthesis as did nerve growth factor resulting in neuronal cell regeneration (16). New biomedical technology devices are needed for biosensing of human physiology and multi-organ screening. The field of bioelectric medicine is an obvious first choice for multi-organ screening if instruments are reliable.

BEM instruments measure electrical properties of organs and tissues through related skin points on the body. These points are frequently acupuncture points, thus these instruments are generically called: electro-acupuncture according to Voll (EAV); electrodermal screening (EDS); or galvanic skin resistance analysis (GSR). Half a century ago, Rosendal demonstrated that application of negative D.C. voltage and steady current to the skin caused the skin resistance to fall (17, 18, 19). Now, modern devices measure electrical resistance by providing a specific electrical stimulus to skin points using computer-controlled ohm meters. Product names and stimulus provided by these devices are LISTEN (5.0 volts), computron (1.3 volts), vega (1.5 volts), dermatron (1.3 volts), interro (5.0 volts), biopath (5.0 volts), mora (1.2 volts), chin (1.2 volts), and photonic (5.0 volts). A standard amount of voltage is applied through a hand-held bar to the body, thus passing direct current to skin points and consequentially moving ions in specific directions. Electrical current is measurable at specific skin points and is characterized by the following: 1) pH; 2) ion movement; 3) the number of ion channels in the cell membrane; 4) the permeability of the cell membranes; and 5) opening and closing of ion channels. Electrical resistance can be calculated from the measured current via Ohm's Law, V = IR (voltage = current x resistance; where resistance = inverse of conductance). Given a specified voltage, a charge accumulates in the skin thus evoking increased permeability in cells of the epidermis and dermis (20, 21, 22). In simpler words, increased permeability results in an increased conductance for the same applied voltage.

There remains hesitation on the part of scientists and clinicians to accept EDS bioelectric medical instruments as useful tools for diagnosis even though these techniques have been available for decades. This hesitation, in part, arises from lack of clarity between different electrodermal screening devices, their calibration and what they reliably measure (23). There are at least four variables that are significant:

- Standard voltage used: the instruments available vary in the voltage applied, some use 1.2 - 2.0 volts while others apply 5.0 volts. Due to the fact that the average surface electrical potential of a grounded human is approximately 3.0 volts; signal-to-noise ratios significantly differ in various instruments (4).
- Standard timing for measurements: electrical conductance is dynamic, fluctuating over time. Measuring times for different instruments vary from a standard 1 second to random lengths of time. Reproducible characterization of conductances depends upon standard ization of timing.
- Consistent skin point location: reliability of measurements depends upon correct point location and consistent pressure on skin points.
- Operator reliability: operator skill and reliability are important if the instruments are to be used for diagnostic purposes.

This manuscript presents scientific support to answer the following question: Do electrodermal screening devices provide accurate diagnostic information to clinicians about their patients? In order to answer this question new analyses of previously published tabulated data are presented in graphic form. Additionally, new data collected from current clinical studies are presented.

THEORY, RELIABILITY AND SCIENTIFIC BACKGROUND OF ELECTRODERMAL SCREENING

The theory of EDS is based on findings that skin conductance at specific points of approximately 1 cm2, differs from the conductance at

skin points surrounding these areas (24). Reports of the magnitude of difference vary from two to six fold on skin (24, 25) and greater than twenty-fold on ear points (26). The conductances of these specialized skin points are approximately 1 x 10-5 mhos in the normal 'healthy state' compared to 5 x 10-6 mhos conductance in the surrounding skin areas (20, 24, 27, 28, 29, 30, 31). This essentially means the healthy state is reproducibly and quantitatively represented by 100,000 ohms of resistance at specific conductance points. Many conductance points coincide with acupuncture points that have been mapped to specific organs and/or to areas of the brain (32, 33, 34, 35). Acupuncture/conduct-ance points are correlated to neurovascular bundles by using radioactive tracers (36) and are thought to contain high densities of cellular gap junctions between cells (37). Rheinhold Voll, a physician and acupuncturist, used electrodermal screening devices on human skin points at acupuncture points in the late 1940's and reported that pathophysiological states could be characterized by measurements of skin conductance (31, 38). Based on his correlations between physical exams and conductance measurements, Voll proposed that inflammatory states in the body were reflected by higher than normal skin conductances while organ degeneration and tissue necrosis were reflected by lower than normal skin conductances. The scientific weakness of Voll's publications in English was that data were lacking, being replaced with descriptive analyses of patients' conditions. Schimmel, Voll's collaborator, presented electrical trace profiles which demonstrated that the amplitude of the conductance and the fluctuations of the conductances over time provided diagnostic information (20).

Many studies successfully correlated electrical conductances at skin points associated with the lungs to clinical symptoms and X-rays of lung disease. One of the first scientific experiments correlating acupuncture points to organs in the body via measurements of electrical conductivities were presented by two British clinicians working at a tuberculosis sanitarium (39). Previous tabulated data by these clinicans of electrical conductance measurements at acupuncture and adjacent non-acupuncture skin points of tuberculosis patients with unilateral lung lesions are for the first time presented in graphic form (Figure 1). Eighteen patients with unilateral lung infiltrations or cavities demonstrated a two-fold higher conductance at acupuncture point LUNG 9, located on the forearm, than the adjacent skin point (16.7 ± 2.5 x 10-5 mhos versus 8.0 ± 2.78 x 10-5 mhos). Larger differences were measured and tabulated at acupuncture point LIVER 8, located on the knee, between tuberculosis patients with and without known liver disease. These data which were previously only tabulated are now graphed in Figure 2 and show that patients with liver inflammations, i.e. liver cirrhosis or acute hepatitis had high electrical conductances of 84.9 ± 81.9 x 10-5 mhos compared to patients with no liver disease who had eighteen fold lower conductances of 4.8 ± 0.03 x 10-5 mhos. These are significant differences in electrical conduct-ances between patients with and without liver disease at LIVER 8.

Bergsmann and Woolley-Hart's data indicated that electrical conductance at acupuncture skin points did associate with specific tissues and did discriminate between health and disease status. Recently, Sullivan et al. (40) found statistically significant confirmations ($P<0.02$) between chest X-rays and electroacupuncture point measurements blindly evaluated in four lung disease patients and 26 healthy controls. LISTEN measurements of electrical conductances of lung skin points in four lung disease patients were 30% below the optimal values of the healthy controls (Brewitt, non-published data).

The cellular features that contribute to electrical conductance may explain why EDS has potentially useful diagnostic value. The cell membrane is electrically asymmetric, created by an unequal distribution of cations and anions on each side of the bilayer surface. This characteristic creates direct current electrical potentials that are maintained at homeostasis under normal conditions (41). Abnormal changes on the external or internal surface of the cell membrane alter the rate of ion transport across it and consequentially change electrical potential (42, 43). Viral infection and bacterial infection as well as cancer, alter the rates of ion transport via effects on the cell membrane or via pH changes in the cell or the extracellular milieu. Viruses leave a protein coat on the external face of the cell membrane and bacteria alter the pH of the extracellular milieu through excessive H+ pumping (8, 44, 45). Cancerous tissues contain higher than normal water and sodium content (46) causing measurable changes in the cancer cells' charge density (47). Ambrose et al. proposed that cellular transformation, as seen during cancer, changes either the number of charged groups attached to the carboxyl-rich chain of proteins or changes the cell's ability to absorb positive ions, thus altering the cell's electrical properties (47). As shown in *Figure 2*, electrical conductance profiles of patients may accurately characterize areas of clinical concern by delineating significant deviations from the normal levels.

PREVIOUS ANIMAL EXPERIMENTS MEASURING BIOELECTRICAL PARAMETERS

The physiologist, A. P. Mathews (48) in 1903 said "Every excess of action, every change in the physical state of the protoplasm of any organ, or any area in the embryo or in the egg, produces, it is believed, an electrical disturbance". Since that time, researchers have found clinically significant differences in healthy and diseased states by measuring skin points for electrical potential and conductance. During the 1930-1940s, Harold S. Burr and associates at Yale published more than sixteen papers on bioelectric potential (skin voltage) and its significance as an indicator of physiological states such as cancer (49, 50, 51, 52, 53), wound healing (54), central nervous system activity (55), drug use (56), sleep (57), development (58, 59), and reproductive cycles (60, 61, 62, 63). Burr's greatest contribution to bioelectromagnetic studies was his finding that significant differences existed between the normal physiological electrical potential and that of pathological tumor formation and cancer.

Burr found that changes in electrical potential of skin points located across the chest correlated closely with tumor formation in cancer-susceptible mice or mice exposed to carcinogens compared to cancer-resistant or control mice (49, 50, 51). Initially it was thought that cancer-susceptible strains of mice had 50% higher electrical potential than cancer-resistant strains (50). However, in a later study, Burr, like Voll, found that abnormal rises in electrical potential correlated with early inflammation in mice and abnormal falls in electrical potential correlated with final formation of papilloma cancers compared to the control mice (51).

Correlations between tissue changes, electrical conductances, and cancerous tumors have been demonstrated using Hewlett Packard capacitance and impedance sensors. Data generated by direct measurements on lung tissue via alternating current (AC) radio frequencies demonstrated that conductivities of deflated feline lungs were twice that of inflated lungs (64). The conductivity of tumors differed when measured at ranges of radio frequencies between 104 to 108 Hz. Tumor conductivities were lower than normal using radio frequencies between 104 and 106 Hz and higher than normal using ra-

dio frequencies of 106 to 108 Hz (65). Thus, the frequency range of the stimulus signal seems to affect the conductivity measured. Progressive stages of tumor development in mice produced statistically significant different conductivities. When tumors were directly measured, conductivities were 6.0-7.5 times higher than normal tissue (66). The high conductivity may reflect either the increased net water content or the reduced potassium content or the altered chemical shifts within the cell membrane (46). Early stages of cancer may produce high conductivities due to retention of sodium and water, while later stages of cancer produce lower than normal conductives due to tissue necrosis. Cancer, like AIDS, results in a deterioration of the body. This deterioration causes histological changes which consequentially produce lower than normal electrical conductance profiles. An example of this is the disrupted architecture of the lymph nodes with involuted germinal centers during the late stages of AIDS (67). Lymph tissue cells that become necrotic during AIDS would be expected to conduct current to a lesser extent than healthy tissue cells due to their disrupted cell membranes *(Figures 3-4)*.

CURRENT CLINICAL DATA USING LISTEN ELECTRODERMAL SCREENING DEVICE

Methods and Instrument:

Electrical conductance measurements on several groups of patients were analyzed by me to test the hypothesis that measurements on skin points can detect differences between controls and patients with either chronic inflammatory conditions, degenerative illness or asymptomatic human immunodeficiency virus (HIV) (Figures 3-4). The EDS device named, Life Information System TEN (LISTEN) (BioSource, Inc., Orem, UT) was selected because it is a modified computer-based ohm meter that can store the dynamics of electrical conductance data during the testing period and then graphically plot the output instantly. This instrument provides a standard 5.0 volts of direct current (D.C.) and standardizes measurements over a one second time period. The patient holds a ground electrode, brass bar, in the palm of the hand, while a test probe is used to touch specific skin conductance points. The body becomes a closed circuit, where a known electric current is output from the LISTEN through the probe, through the body, and back to the LISTEN through the ground electrode. The LISTEN measures the amount of electrons that flowed while the circuit was closed. The LISTEN provides a significant electrical signal above the background voltage of the skin, standardization of measuring times, and quantitative output from which data collected between patients can be compared.

Points selected for analyses were five of Voll's conductance points related to the peripheral immune system plus four traditional Chinese acupuncture points related to the spleen. The peripheral immune system points (associated with lymphatics, joints, and connective tissue) are often involved with chronic inflammatory responses, and are not considered significant by the Chinese. The spleen is not considered essential by conventional medicine, and is considered 'core' to the vitality of the person by the Chinese. Electrical conductances of these nine points were measured on each patient during their first visit to the University Health Clinic in Seattle, Washington. The mean values of five peripheral points and the mean values of four 'core' spleen points were calculated for each patient and then the mean values of each of the two categories for all the patients in each group were determined. The two categories for each group were plotted *(Figure 3)*.

Results:

Electrical conductance measurements on different patient groups were analyzed for differences at immune-related points between non-viral, non-cancer controls and patients with various clinical symptoms involving the immune system. *Figure 3* demonstrates that control patients ($n = 34$) had conductances within the normal range (45-55 relative units) in both the peripheral immune and spleen areas. Patients with chronic inflammatory conditions ($n = 22$), such as carcinoma in situ, chronic and symptomatic Epstein Barr infection, rheumatoid arthritis, and leukemia had higher than normal electrical conductances in peripheral immune system points ($P<0.001$). The conductance of acupuncture points points related to the spleen remained within the normal range, however were statistically different from the controls ($p<0.001$). Patients with degenerative diseases ($n = 7$), i.e. terminal stages of cancer or symptomatic AIDS, had electrical conductances at spleen points below the normal range ($P<0.001$). The conductances of peripheral immune points remained in the normal range however were statistically different than the controls ($P<0.02$). HIV+ asymptomatic patients ($n = 10$), i.e. in earlier stages of the disease process had electrical conductances that were higher than normal in the peripheral immune areas ($P<0.02$) and were normal in the spleen points.

The electrical conductances at each of the nine skin points tested in each patient population is shown in *Figure 4*. The conductances of all nine points for control patients fell within the normal range *(Fig. 4a)*. The distribution around the normal range was small as indicated by the small standard error of the mean. In contrast, there was a distinct hyper-conductivity for patients with chronic inflammation *(Figure 4b)*. A majority of the points (seven out of nine, 78%) rose above the normal range, especially in those points labeled JO, LY, LY1a, LY4, and FI which Voll correlated to joints, lymphatics, lymph drainage in the throat, lymph glands in the lungs, and connective tissue, respectively (35). The points related to the spleen were closer to the normal range in patients with inflammatory conditions. There was a striking difference between the 'control' group and patients with degenerative illnesses such as symptomatic AIDS or cancer *(Figure 4c)*. All of the electrical conductances of patients with degenerative illnesses also were significantly lower than the patients with inflammatory problems. All of the points related to the SP (spleen) acupuncture meridian were lower than the normal ranges in the degenerative illnesses.

Table 1 provides a two-tail t-test statistical analysis of each of the data points. The data in *Figures 3-4* demonstrate that the LISTEN device is capable of characterizing healthy and pathological conditions based on changes in electrical conductances. This new technique will provide a useful diagnostic tool for evaluating systems in the body that are difficult to measure by conventional means, such as the spleen, the lymphatics and the connective tissues. These human data confirm the scientific research conclusions of Burr and the statements made by Voll that inflammation correlates to hyper-conductance and degenerative disease correlates with hypo-conductance.

TIME SERIES ANALYSIS OF ELECTRICAL POTENTIAL FROM PAST IN VIVO STUDY

The original study in 1940 of Harold S. Burr

Burr and associates conducted a time series experiment with normal mice of the genetic strain called CBA and the same strain of mice developing papilloma tumors caused by bi-weekly application of a carcinogen, 0.5% solution of benzpyrene in benzene (51) Their ex-

	Control vs inflamed	Control vs Degenerative	Control vs asymptom. HIV+	Inflamed vs degenerative	Inflamed vs HIV+	Degenerative vs HIV+
JOCR	0.002	0.519	0.318	0.032	0.085	0.747
LYCR	0.027	0.031	0.114	0.0001	0.891	0.002
LY1aR	0.0001	0.003	0.0007	0.0001	0.077	0.003
LY4R	0.032	0.019	0.194	0.0059	0.0025	0.1042
FICR	0.004	0.958	0.335	0.0305	0.1519	0.424
SPCL	0.012	0.0255	0.4858	0.002	0.0304	0.1192
SP1L	0.619	0.0069	0.0001	0.009	0.002	0.052
SP2L	0.125	0.001	0.0501	0.002	0.678	0.006
SP3L	0.001	0.012	0.0601	0.0001	0.0857	0.0013

Table 1: Two-tailed t-test on statistical significance of electrical conductance data. Probabilties that measurements are different within specific confidentiality intervals are given. Statistically significant results are in bold type.

periment was to observe the electrical phenomena and physiological changes associated with painting on the skin benzpyrene in benzene (treatment) or with only benzene (control) compared to normal mice. The three different categories they observed were: 1) an inflammatory reaction; 2) the formation of papilloma; and 3) the development of neoplasms. Burr's data were not graphed previously, rather published in a table format. Now, for the first time *Figure 5* graphically represents electrical potentials of the normal mice versus the mice painted with benzypyrene in benzene. The group of mice receiving the benzene only are not shown. Burr measured electrical potential at skin points across the axillary areas at the same time of day every two weeks (51). Electrical potential differs from electrical conductance in that the former measures potential energy whereas the latter measures a response to a stimulus current. These data of electrical potential, plotted from his raw data illustrate changes in the same group of animals over time. Both the benzene (not shown) and benzpyrene *(Fig. 5b)* applications caused an inflammatory response for eight to ten weeks. After this period the electrical potentials returned to normal in the benzene group, while the benzpyrene group returned to normal for only two weeks more after which a wave of hypo-electrical activity occurred. The amplitudes of the oscillations in the normal mice *(Fig. 5a)* differed significantly from mice developing papilloma tumors *(Fig. 5b)*. Burr observed that repeated exposure to carcinogens caused systemic metabolic changes in the animals which first expressed as inflammation (hyper-conductivity) and later as cancer (hypo-conductivity) (51).

New analyses of Burr's experiment:

Quantitative time series analyses of Burr's data presented in Figure 5 was necessary to gain greater clarity into the oscillatory significance of electrical potential in healthy mice versus mice developing papillomas. This analysis had not been perfomed before, thus was a new quantitative method to confirm or challenge Burr's conclusions that electrical conductance measurements significantly distinguished between health and disease states. Time series analysis provides a quantitative approach for describing and evaluating oscillatory growth. Fourier analysis is a method that discovers hidden tendencies for oscillations of a given frequency to appear in the data. The greater the amplitude in a Fourier transformation, the greater the confidence that a significant oscillation is represented. Fourier transformation resolves time-dependent data into regular periodic components. Fourier transforms of the data in *Figure 5* identified specific oscillatory periods for the healthy mice compared to the carcinogen-treated mice *(Figure 6)*. Both groups of mice contained an oscillatory period in common at approximately ten weeks. This common period shows the reproducibility in the measurements since the mice are from the same genetic strain and therefore contain cellular similarities. The Fourier analysis also identified two statistically different oscillatory frequencies; one characteristic of a healthy state and one characteristic of an abnormal state. Fourier transforms identified a high frequency oscillatory period every 2 weeks for the healthy CBA mice. The tumor forming mice lost this normal high frequency oscillation. Instead, the abnormal mice developed one long term oscillatory period of 32 weeks, i.e., the entire length of the study. No such oscillatory period was present in the healthy mice.

One interpretation of these data is that disease states contain both common and separate electrical potential compared to the healthy state. Mice with tumor formation contained a long slow sinusoidal oscillation of 32 weeks that was not present in the healthy state. The correction factor for electrical potential was at least three and perhaps sixteen times slower than in the healthy situation. Normal 'healthy' mice retained self-correcting electrical potentials that occurred at least every two weeks and at most every ten weeks. The physiological significance of these data are interpreted to mean that 'health' correlates with a frequent oscillatory period with a low amplitude around a baseline value. Tumor formation may correlate with a shift from the low amplitude, high frequency oscillation to a high amplitude, low frequency oscillation around the baseline value. Cancer-susceptible mice appeared to have inadequate corrections back to baseline value once electrical potential shifted away from normal ranges. Rapid return to normal electrical profiles may be a useful parameter to evaluate in the clinical setting during changes from a normal to pathological state.

The hypothesis that a healthy state responds to disruptions of electrical conductance by more rapidly returning to normal compared to a chronic inflammatory or degenerative states was tested in the following way. Patients coming to University Health Clinic for treatment every three to seven weeks were measured for electrical conductances at peripheral immune system points *(Figure 7)*. Patient groups were defined as: chronic inflammation; degenerative conditions such as, terminal cancer or AIDS; and controls (neither inflammation or degenerative). Each point in *Figure 7* represents the means of five electrical conductances of peripheral immune points in each patient group over time. Each of these patients made an appointment to the Clinic every three to seven weeks. The control patients remained within the normal range throughout their visits to the Clinic. The electrical conductances of patients with chronic inflammatory states were above the normal range during their first visit to the Clinic. By the second visit they precipitously dropped and slowly approached the normal range by the six to eight month of treatment. The degenerative conditions of patients followed for four months remained below the normal range throughout the course of the study without approaching the normal range. These data demonstrate that hyper-conductivity is reproducibly associated with tissue inflammation and that hypo-conductivity is associated with tissue deterioration. Additionally, the data demonstrate that time dependent corrections in electrical conductance, i.e. returning back to the normal levels, vary according to the patients'state of health. Patients with normal health problems remain in the normal range of electrical conductance within the peripheral immune system throughout their treatment. Patients with inflammatory conditions take considerably more time to return to normal levels of electrical conductance in the peripheral immune system. Patients with terminal illness, are fragile and may get worse before they get better, depending upon their treatments. Further experiments are warranted to understand the ability and responsiveness of different types of patients to change electrical conductances over time and with different types of treatment.

CONCLUSION

Historically and currently, EDS instruments characterize differences between inflammatory and degenerative conditions. Electrical conductance data reviewed here correspond with histological reports. Chronic inflammation, benign tumors, and early stages of cancer create pressure on connective tissue cells (68) which result in measurable cellular charge density increases. The data presented in Figures 3 and 4b demonstrate that electrical conductances are raised in skin points associated with connective tissue as well as other, but not all skin points during states of chronic inflammation, chronic Epstein Barr viral infection, benign tumors, and early cancer. Chronic viral infection is considered a chronic inflammatory state because it is histologically associated with the presence of lymphocytes and macrophages plus the proliferation of blood vessels and connective tissue (68). Early stages of HIV infections are histologically characterized by follicular hyperplasia in the lymph nodes (67). *Figure 4d* demonstrates hyperconductances in patients with asymptomatic HIV infection as would be predicted from states of hyperplasia. Excesssive cell proliferation, as seen during development, has previously been correlated with increased electrical potential (59). Long term pressure on connective tissue eventually leads to atropy of parenchymal cells next to expanding tissue with consequential loss of charge density and lower electrical conductances. Late stages of cancer are characterized by progressive infiltration, invasion, and destruction of surrounding connective tissues (68). Late stages of AIDS are histologically characterized by deteriorated germinal centers within lymph nodes (67). The data presented in *Figures 3* and *4c* demonstrate that electrical conductances of immune system points related to lymphatics and spleen were lower than normal, coincidental with histological findings of deteriorated cell membranes.

In clinical practice, EDS instruments are useful as diagnostic supplements to blood tests, radiographic imaging, and case histories. The integration of reliable and valid bioelectric medical instruments into the clinical setting augments the ability to rapidly evaluate tissues such as the spleen, lymph nodes, and connective tissue, which are difficult or impossible to assess by conventional test procedures. As the medical community has discovered with HIV, accurate evaluation of the lymph nodes and spleen are more effective than blood tesing in understanding when the immune system will fail under the burden of HIV infection (67, 69). Given reliable electrodermal screening instruments, early diagnosis of chronic viral infections might be possible via measureable changes in the electrical conductances of patients. This early and quantifiable diagnostic measurement could set the stage for early, hence more effective treatment. Bioelectric medicine offers clinicians new quantitative methods for evaluating subtle electromagnetic changes in humans.

Acknowledgements: I thank Shahram Vaezy, Ph.D. for his expert advice plus statistical and Fourier analyses of data. I also want to thank the following readers for their beneficial comments and interest in bioelectric medicine: John I. Clark, Ph.D., Paul Framson, Ph.D., Monica Orellana, Ph.D., and Leanna J. Standish, Ph.D., N.D. I acknowedge the assistance of Ann Ready in compiling these data for analyses.

Figure 1

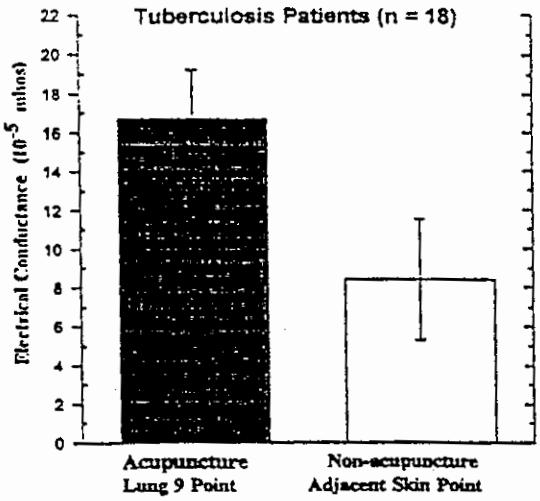

Figure 2

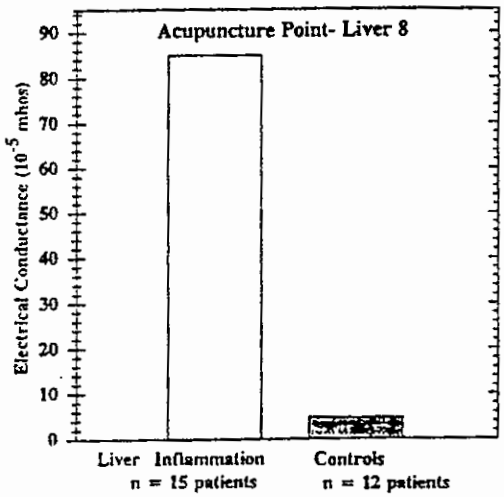

Figure 3

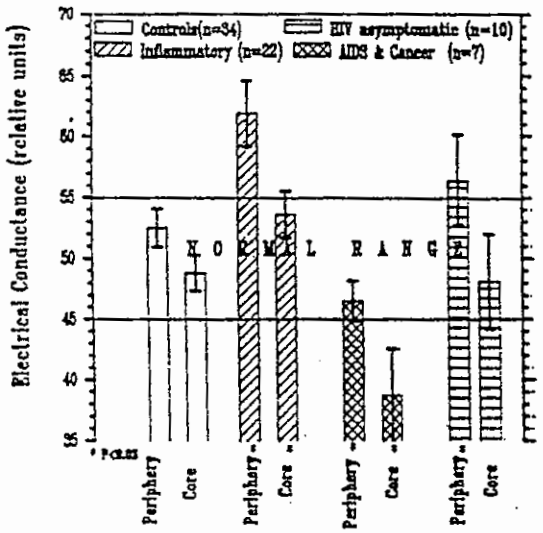

Figure legends

Figure 1. Evaluation of electrical conductance at acupuncture and adjacent skin points of tuberculosis patients (39). The raw data of resistance were inverted and plotted as histograms of electrical conductance in this graph. A homemade nine-volt resistor with an electronic micro-ammeter was used to register current (70). Electrical resistances were determined for eight patients with unilateral lung infiltration and ten patients with unilateral cavities from the registered current. The standard deviations were determined from the means of the two data points given in the table for acupuncture point LUNG 9 and the four points given in the table for adjacent skin points.

Figure 2. Evaluation of electrical conductance in tuberculosis patients with and without related liver disease (39). Electrical resistance at acupuncture point LIVER 8 in patients (n = 15) with liver inflammations (recent hepatitis or alcoholic cirrhosis) and patients without liver complications (n = 12) using the same equipment as described in Figure 1. The raw data were converted to electrical conductances. Standard deviations are not presented due to the fact that only two means were given in the table for the 15 patients with liver inflammation.

Figure 3. Mean values of electrical conductances in four patient groups: 1) controls (no chronic viral symptoms or complaints and no cancer); 2) chronic inflammation; 3) AIDS and cancer and; 4) asymptomatic seropositive for HIV infection. Data were collected using the EDS instrument called the LISTEN, which applies a standard five volts DC and records current for a one second time frame. Measurements were based on Rheinhold Voll's standardized scale, converting electrical resistance from a logarithmic scale, ranging from 0 ohms to 2.0 x 106 ohms, to a linear scale between 0 and 100 units, with 0 representing absolute resistance and 100 representing near absolute conductance (the inverse of resistance). The value of 50 units on his standardized scale represented the normal physiological range of 100,000 ohms of resistance at specific skin points. This finding of optimal electrical resistance equalling 50 has been closely reproduced by others; using the Dermatron, 57.74 units ± 1.92 Std. Dev. (71) and using the LISTEN, 50.88 units ± 1.48 Std. Dev. (Brewitt, non published observations). Patients were defined as 'controls' if they did not have a chronic viral illness, nor either of the other three conditions. Patients with chronic inflammatory conditions were defined by rheumatoid arthritis, chronic symptomatic Epstein Barr viral infection, asymptomatic chronic lymphocytic leukemia, symptomatic uterine fibroids, and chronic non-invasive squamous cell carcinoma in situ. Chronic inflammation was defined by clinical symptoms that could be associated with the presence of lymphocytes and macrophages and involving the blood vessels and the connective tissue (63). Degenerative illness was defined by patients with terminal cancerous tumors in the brain and lungs and by patients with AIDS (CDC classification 3B and 3C, i.e. CD4 counts below 100 cells/ul plus AIDS defining opportunistic infections). HIV+ patients were asymptomatic with CD4 counts above 150 cells/ul. Standard error bars are shown.

Figure 4 (following page). Mean values of electrical conductances at individual skin points represented in Figure 3. These data provide information regarding the range of variation between specific points. The Voll skin points measured on the thumb were: LYC, LY1a, LY4 (associated with lymphatic control, lymph drainage throat, lymph glands in lungs, respectively) and on the second toe were JOC (joints) and third toe were FIC (connective tissue). Traditional acupuncture points measurements on the left toe were: SPCL, SP1L, SP2L, SP3L (spleen points). All points for control patients fall within in normal range (4a). Note that the all the points in the 'peripheral' immune system (as defined in Fig. 3) rise above the normal range for patients with inflammatory conditions (4b) and all of the points in the 'core' immune system fall below the normal range in patients with degenerative diseases (4c). HIV+ patients had points that were significantly above normal in periphery and below normal in the core spleen (4d). Standard error bars are shown.

Figure 4a

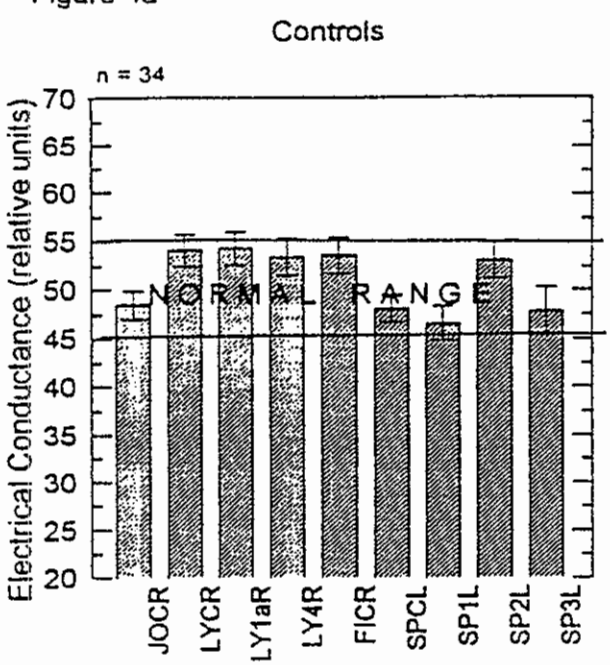

Figure 4b

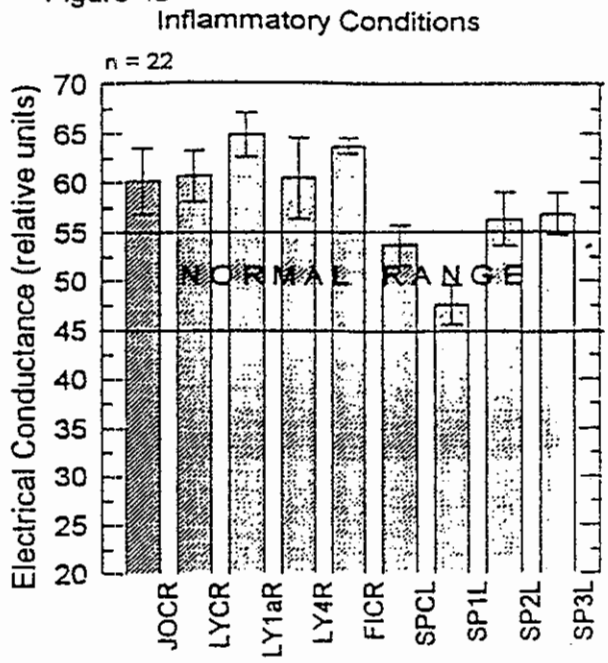

Figure 4c

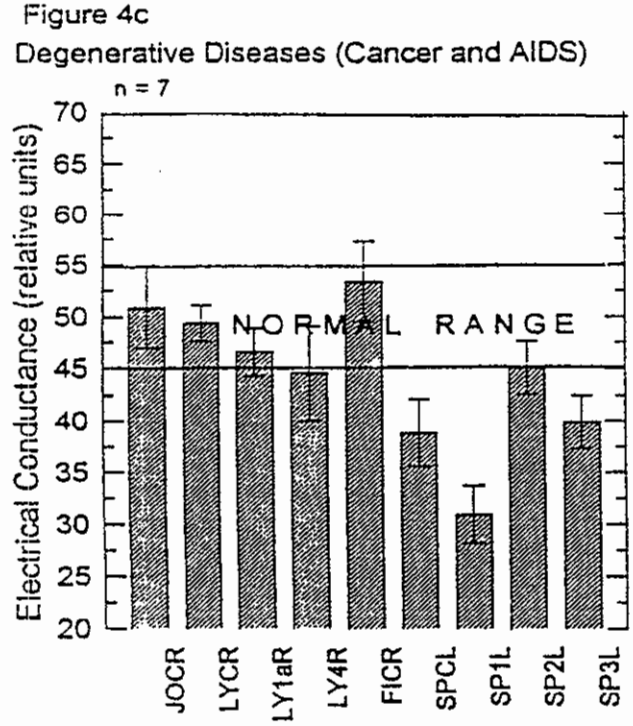

Figure 4d

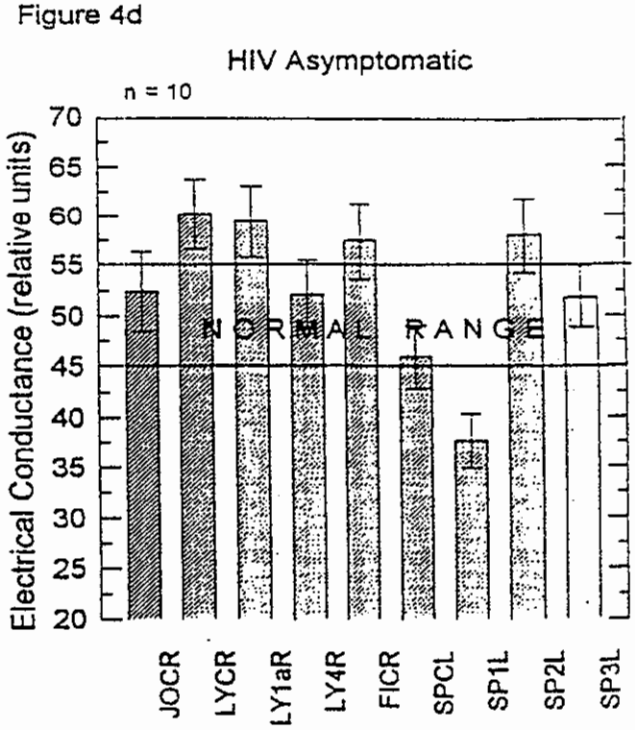

Figure 5a

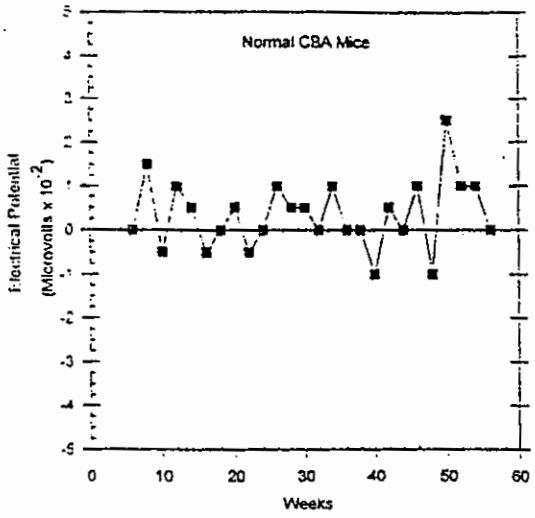

Figure 5b

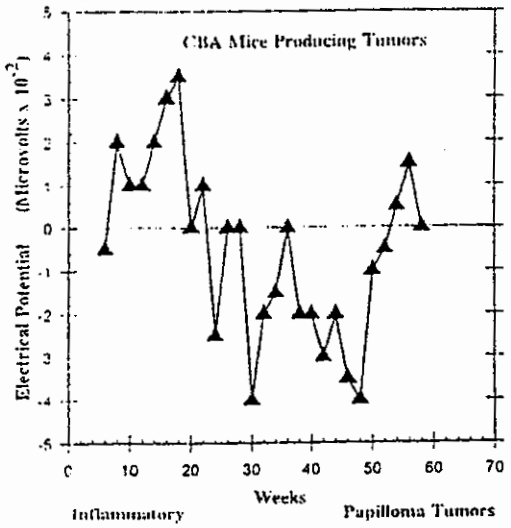

Figure 6

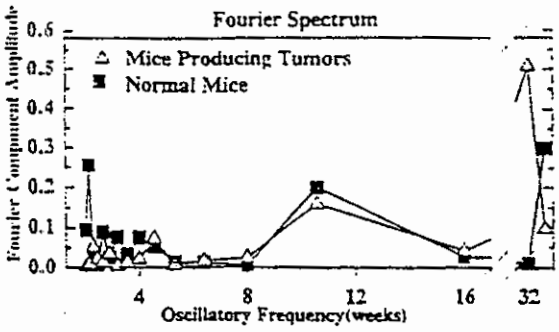

Figure 7

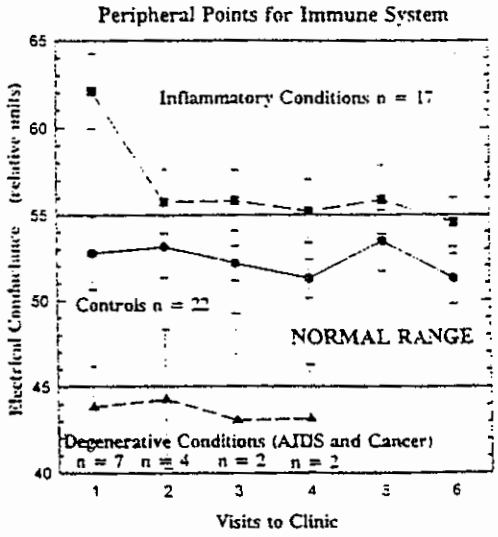

Figure 5. All measurements were taken by H. Burr and associates in 1940 between 1:30-3:00 P.M. to prevent diurnal variations (51). Data presented here were extrapolated from their graphic representation. Note the narrow variance in electrical potential of the normal (control) mice (5a) compared to the mice developing carcinomas (5b). Amplitudes in electrical potential oscillated above the normal range in the mice during the early inflammatory response to benzpyrene and below the normal range during appearances of papilloma formation.

Figure 6. Fourier transform analysis of Figure 5. The Fourier components are shown on the Y-axis. The higher the amplitude of the Fourier component, the more representative that specific oscillatory frequency is to the data set, i.e. electrical potential periodicities. The frequencies of oscillatory periods in the data sets are shown on the X-axis. Normal mice have significant oscillations in electrical conductance every two, eleven, and thirty-four weeks. Mice developing tumors have significant oscillations in electrical conductance only every eleven and thirty-two weeks.

Figure 7. Electrical conductances of patient groups over time. Mean values of the electrical conductances identified as peripheral points with standard error bars are shown. Patients coming for treatment at the Clinic were measured at the skin points associated with the peripheral immune system every three to seven weeks, i.e. during a six to eight month period. The number of cancer and AIDS patients treated over time at the Clinic decreased (visit 1 = 7 patients, visit 2 = 6 patients, visit 3 = 3 patients, visit 4 = 2 patients). Patients in the control group (n = 22) maintained conductances within a range of 51.2 to 53.5 units throughout the time series. Patients with inflammatory conditions (n = 17) remained higher than normal until the final visit with conductances ranging from 54.6 to 62.1 units and patients with degenerative illnesses remained lower than normal with values ranging from 43.1 to 44.3 units.

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