Are There Electrical Devices that can Measure the body's Energy State Change to an Acupuncture Treatment? Part I, The Meridian Stress Assessment (MSA-21) Device

By

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Introduction

The general field of energy medicine is growing strongly but is still in great need of reliable monitoring instruments to assess the relative energetic state of humans with respect to a healthy/pathology ratio. According to ancient Chinese medical therapy, the overall energy state and health condition of a human is largely determined by the flow of a substance called Qi through a system of channels, called meridians, distributed throughout the human body. Qi, is thought to flow into and out of the body via a network of acupuncture points and via the meridian network, to nourish various organ systems, neural systems, muscle groups, etc., of the coarse physical body[(1)]. Imbalances between Qi flow in the various meridians is thought to over-nourish various coarse physical body systems and under-nourish others, leading eventually to different types of pathology development in such systems. Stimulation of specific acupuncture points via one of a variety of procedures, is thought to perturb the Qi-flow pattern towards optimal balance for the body and create a lessening or removal of the growing pathology. The NIH consensus report states that acupuncture has been quite helpful for lessening the severity of a variety of human disorders [(2)]. It is therefore quite natural that commercial devices for evaluating the condition of the meridian energy state would be seriously considered by those involved in complementary and alternative medicine.

We recently selected two commercial instruments for an in-parallel study of the following question "Can they meaningfully discriminate the effects of acupuncture treatment on the body's energy state?" In this paper, we report on experimental results using Bio Meridian's MSA-21 device [(3)], a highly advanced electro-dermal monitoring system which measures the time-varying current response of the skin to a constant voltage applied to an acupuncture point. In part II of this series of papers, we report on experimental results using Korotkov's Gas Discharge Visualization (GDV) Device, a sophisticated modern-day version of Kirlian photography[(4)] .

In this exploratory study, 33 randomly-chosen, clinically healthy subjects were utilized in a fashion such as to act as their own control. Data from each device was gathered before and after double-blind needling at both true and sham acupuncture points. The study required two visits by each subject for needling at five different acupuncture points, one for true and one for sham needling. The single research hypothesis was "If energy is added to and/or redistributed in the body via true acupuncture needling, as contrasted with sham acupuncture needling, a worthy measurement instrument must (at least) be able to discriminate this energy change contrast in a statistically significant fashion." Indeed, the MSA-21 instrument passed this test in good order and provided much useful adjunct information as well.

Experimental Procedures

A. The Device: The BioMeridian MSA-21 device is a much-upgraded version of the original Voll Dermatron devise [5] and, as such, measures the relatively slow current flow response of the skin (~10-100 sec) to a small (~ + 2 volt) DC voltage applied to the skin. The electric circuit, consists of (1) a large cylindrical electrode held in the subject's hand, (2) the MSA-21 device, (3) a small (~ 1mm) contact electrode pressed against a point on the subject's skin by the operator and (4) the return connection through the subject's body to the large electrode. For a healthy subject, an electric current in the ~ 8-10 micro-amp range is generated in response to this +2 volt application. The attached computer converts this data to electrical impedance, which is displayed on a 0-100 scale with 50 indicating a normal, healthy person response. A reading of less than 50 is defined as a degenerative condition; a reading of more than 50 is defined as an irritated situation. A second important measurement is called the "indicator drop" (I.D.), wherein the conductance number, after slowly rising to its maximum value, drops fairly quickly to a final value with time. For a normal response (~ 50), the I.D. occurs within ~ 1-3 seconds and the electrical impedance maintains a constant value until the full measurement time elapsed (~ 10-20 sec). When there is an abnormal response (above or below 50), the I.D. is much longer (~ 20-60 secs), depending upon how far away from 50 the maximum reading occurred.

B. The Human Protocol: The study required two visits, ~ 3 days apart, to the Shealy clinic. During one visit, subjects received "authentic" acupuncture and, during the second visit, they would receive "sham" acupuncture, both being administered by one of us (CNS). At random, 18 of the subjects were chosen to receive authentic acupuncture during the first session, while the other 16 received sham acupuncture and vice versa for the second session. Five acupuncture points were selected for needling: LI-4, right and left (Large intestine), LR-3, right and left (Liver) and GV-20 (The Governor Vessel). The needles were left in place for 15 minutes.

C. Each subject was comfortably seated in a recliner chair within a room of comfortable temperature (~72 °F). After approximately 5 minutes of acclimation to the room, the subject's temperature and heart rate were recorded by a nurse. The subject was then positioned so that baseline readings could be measured by the MSA-21. These measurements consisted of 44 standard measurements for both the authentic and the sham points on each subject, 24 of which were located across both hands and 20 across both feet (see Fig 1). Baseline readings were repeated twice to assess the reproducibility of the measurements acquired by this equipment. All MSA-21 measurements were made by an accomplished practitioner with (NRR) watching the process.

Point ID	Meridian	Max	Min	Rise	Fall	Drop
LY-1-2*R	Lymphatics	48	48	24	0	0
LU-10c*R	Lungs	50	50	60	0	0
LI-1b*R	Large Intestine	46	46	28	0	0
NE-1b*R	Nervous System	54	53	49	0	1
CI-8d*R	Circulation	47	47	30	0	0
AL-1R	Allergies	45	45	25	0	0
AL-1b*R	Allergies	48	48	45	0	0
OR-1b*R	Cellular Metabolism	46	46	24	0	0
TW-1R	Endocrine System	45	45	28	0	0
TW-1b*R	Endocrine System	47	46	38	0	1
HE-8c*R	Heart	46	46	25	0	0
SI-1b*R	Small Intestine	44	44	18	0	0
LY-1-2*L	Lymphatics	49	49	36	0	0
LU-10c*L	Lungs	46	46	21	0	0
LI-1b*L	Large Intestine	46	46	27	0	0
NE-1b*L	Nervous System	52	51	32	0	1
CI-8d*L	Circulation	47	47	43	0	0
AL-1L	Allergies	47	47	47	0	0
AL-1b*L	Allergies	47	47	32	0	0
OR-1b*L	Cellular Metabolism	51	51	33	0	0
TW-1L	Endocrine System	49	49	45	0	0
TW-1b*L	Endocrine System	48	48	23	0	0
HE-8c*L	Heart	50	50	33	0	0
SI-1b*L	Small Intestine	50	50	29	0	0
PA-1a*R	Pancreas	49	49	23	0	0
LV-1a*R	Liver	49	49	31	0	0
JO-1b*R	Joints	48	48	54	0	0
ST-44b*R	Stomach	49	49	58	0	0
FI-1b*R	Connective Tissues	60	59	30	0	1
SK-1-3*R	Skin	51	51	51	0	0
FA-1b*R	Fatty Tissues	51	51	38	0	0
GB-43b*R	Gallbladder	51	51	40	0	0
KI-1-3*R	Kidneys	53	53	41	0	0
UB-65R	Urinary Bladder	53	53	30	0	0
SP-1a*L	Spleen	52	52	25	0	0
LV-1a*L	Liver	52	52	25	0	0
JO-1b*L	Joints	49	49	23	0	0

Weakened Balanced Stressed

Figure 1 A sample printout from the BioMeridian MSA-21 program.

Once the baseline measurements were taken, the subjects reclined in a chair and the acupuncturist (CNS) emplaced the five needles. Only CNS and his nurse knew whether the needle placement was authentic or sham. The needles were left in place for 15 minutes and then removed. At 5 minutes and 30 minutes after needle removal, repeat MSA-21 measurements were made. The subjects returned approximately three days later at approximately the same time of day to repeat the measurement process for the second type of needling.

The measurements associated with authentic acupuncture are compared with those from the sham acupuncture needling in the next section. The statistical significance was assessed via both the one-sample t-test and the paired t-test. The sham acupuncture treatment was compared to the two pre-treatment measurements to evaluate possible placebo effects, while these two pre-treatment measurements were utilized to evaluate reproducibility of the individual measurements.

RESULTS

There were 34 subjects measured on two occasions in this study with 44 acupuncture points measured 4 times on each occasion (2 pre- and 2 post-needling). Thus, the raw database includes a total of 352 measurements for each subject for a total number of measurements of 11,968. The representative set of MSA-21 measurements for a single subject is presented in Appendix A as an example of the data gathered. One of the baseline sets of readings for all points measured is presented in Figure 1 as an illustration. The five column headings are defined as follows:

Max: The maximum registered electrical impedance, Z, reading,
Min: After the max, the minimum registered electrical impedance reading,
Rise: The time for Z to reach the max in seconds,
Fall: The time between the max and min in seconds and
Drop: The reading difference, Z max – Z min.

The large volume of data allowed for multiple approaches to data analysis. For the initial work recorded in this paper, only the Max value was singled out and placed in a spreadsheet for detailed study at this time. NRR is the librarian for accessible storage of all the 11,968 datum values on these 34 subjects.

Based on the historical Asian perspective that pathology presents itself as increased differences between left-side and right-side readings for the same acupuncture points, the data were separated into right and left side groupings. A further separation into hands and feet groupings was also made. For data analysis, the following steps were taken:

(1) A type of normalization procedure was invoked by subtracting 50 from each measured value,
(2) The normalized baseline values were averaged for each acupuncture point (A.P.),
(3) Right-side averages and left-side averages for all post-needling measurements were made,
(4) Right-hand, left-hand, right-foot and left-foot averages for all post-needling measurements were also made and
(5) A delta (Δ)-value for each A.P. was determined by subtracting the average baseline reading at each A.P. from the 5-minute and 30-minute post-needle removal reading for that A.P.

Our expectation was that any change in measured "energy effect" for the delta-values should be greater for the authentic acupuncture than for the sham acupuncture. We also expected that, for sham acupuncture, the delta-values should be very small.

Table 1 presents the differentials of the delta-values for the authentic (real) minus the sham A.P. needling for the averaged right-side and left-side of the body for each subject. Here, symbology of the variables is:

A_b = averaged baseline reading,
A_5 = averaged value across all points at 5 minutes post-needling for authentic acupuncture,
A_{30} = averaged value across all points at 30 minutes post-needling for authentic acupuncture,

A_{br}, A_{bl}, A_{5r}, A_{5l}, A_{30r} & A_{30l} are for only right-side or left-side averaging and replacing A by S yields sham vs. authentic A.P. needling.

$\Delta_{5r,l} = |A_5 - A_b|$ for both the right and left sides and,

$\Delta_{30r,l} = |A_{30} - A_b|$ for both the right and left sides and,

$\varsigma_{5r,l} = |S_5 - S_b|$ for both the right and left sides and,

$\varsigma_{30r,l} = |S_{30} - S_b|$ for both the right and left sides and,

where $|\ |$ stands for taking the absolute value of the result.

From the above, $\Delta_{5r,l} - \varsigma_{5r,l}$ and $\Delta_{30r,l} - \varsigma_{30r,l}$ were determined. If the result was greater than zero, it was awarded a one (1) while, if it was less than zero, it was awarded a zero (0). This is analogous to a coin flip result for random choosing. Finally, the (1)'s were summed across all subjects.

From Table 1, one notes that the total differential delta values for authentic (real) acupuncture on the right side of the body at 5 minutes and 30 minutes was 51.5% and 60.6%, respectively, while for the left side of the body they were 48.5% and 66.7%, respectively. Overall, when one includes all readings at 5 and 30 minutes for both left and right sides of the body, 84.9% of the subjects had a greater delta-value for the real (authentic) than the sham acupuncture. A statistical analysis of this data via a one-sample t-test for $(\Delta - \varsigma)_{r,l}$ at 5 and 30 minutes being greater than zero gave $p < 10^{-4}$ for all cases with the t statistic being 5.83, 7.02, 5.49 and 8.00 for 5_r, 30_r, 5_l and 30_l, respectively. The expanded case of any $(\Delta - \varsigma) > 0$ also gave $p < 10^{-4}$ with a t-statistic value of 13.39.

Table 1

Real minus Sham Averaged Differentials Relative To Baseline For Right and Left Side of The Body.†

ID	Right: REAL minus SHAM				Left: REAL minus SHAM				Any Real
	RT 5 min		RT 30 min		LT 5 min		LT 30 min		
7	-2.273	0	-1.455	0	-0.909	0	-3.636	0	0
30	-1.455	0	-0.636	0	-0.091	0	-1.455	0	0
14	-0.182	0	-5.591	0	-4.909	0	-6.364	0	0
18	-2.682	0	1.091	1	5.864	1	0.591	1	1
19	-1.045	0	2.000	1	-0.773	0	2.227	1	1
15	-1.091	0	0.000	0	-0.591	0	-1.273	0	0
1	-1.227	0	-0.909	0	0.682	1	0.818	1	1
34	0.136	1	3.318	1	-0.273	0	1.045	1	1
31	-0.818	0	-1.227	0	0.955	1	0.182	1	1
13	-0.727	0	-0.727	0	1.409	1	0.273	1	1
12	2.000	1	1.727	1	1.682	1	-0.318	0	1
26	0.636	1	1.591	1	-0.909	0	-1.864	0	1
9	0.136	1	-5.909	0	-0.045	0	-2.636	0	1
16	-0.682	0	0.091	1	1.773	1	0.591	1	1
10	0.773	1	-1.000	0	-2.318	0	-1.045	0	1
3	4.364	1	3.955	1	2.955	1	2.773	1	1
22	0.182	1	-1.091	0	-0.545	0	0.636	1	1
29	0.045	1	0.409	1	1.091	1	2.500	1	1
21	-0.409	0	-2.409	0	-1.455	0	-5.682	0	0
8	3.818	1	2.227	1	1.818	1	1.455	1	1
20	-2.591	0	1.000	1	-1.409	0	3.955	1	1
32	-1.500	0	1.182	1	-2.136	0	-0.591	0	1
33	0.227	1	1.545	1	-0.909	0	0.545	1	1
11	0.773	1	0.636	1	2.818	1	2.864	1	1
6	0.636	1	-1.364	0	0.045	1	-0.545	0	1
5	1.364	1	1.909	1	2.045	1	1.409	1	1
4	-0.409	0	2.364	1	0.545	1	2.545	1	1
28	2.773	1	2.136	1	3.909	1	1.045	1	1
27	-3.364	0	3.636	1	-2.682	0	5.682	1	1
23	0.818	1	1.091	1	-0.091	0	0.682	1	1
25	3.091	1	0.273	1	0.318	1	2.409	1	1
24	1.682	1	0.545	1	-0.682	0	0.318	1	1
2	-1.318	0	-0.136	0	0.545	1	0.318	1	1
		17		20		16		22	28
	Percent Response	51.515		60.606		48.485		66.667	84.848

† $\Delta_{5r,l} - \varsigma_{5r,l} = |A_5 - A_b| - |S_5 - S_b|$

$\Delta_{30r,l} - \varsigma_{30r,l} = |A_{30} - A_b| - |S_{30} - S_b|$

A second data analysis approach looked at the differential deltas between the right and left sides of the body and comparing the authentic and sham needling for three different cases: (1) total body, (2) hands only and (3) feet only. Our expectation was that both $\{|\Delta_{5r} - \Delta_{5l}| - |\varsigma_{5r} - \varsigma_{5l}|\} > 0$ and $\{|\Delta_{30r} - \Delta_{30l}| - |\varsigma_{30r} - \varsigma_{30l}|\} > 0$. Table 2 presents the results for the total body where, at 5 and 30 minutes respectively, p=2.8x10-3 and 5x10-4 with the t-statistic being 2.97 and 3.59. Thus, 63.6% of the subjects had positive values for 5 minutes, growing to 72.7% at 30 minutes and, overall, for a positive at either 5 or 30 minutes, this grew further to 84.8%.

Table 3 presents slightly different data for the hands only case where our expectation was that (a) $\Delta_{5rh} - \varsigma_{5rh} > 0$, (b) $\Delta_{30rh} - \varsigma_{30rh} > 0$, (c) $\Delta_{5lh} - \varsigma_{5lh} > 0$ and (d) $\Delta_{30lh} - \varsigma_{30lh} > 0$. The statistical analysis for a, b, c and d, respectively, gave $p < 10^{-4}$ for all cases with the t-statistic being 4.56, 4.86, 4.86 and 9.24. For the right hand column, $p < 10^{-4}$ and the t-statistic is 13.39. For the right hand, only 39.4% of the subjects had a greater response to authentic than to sham needling at 5 minutes, which grew to 42.4% at 30 minutes. For the left hand, the same assessment gave 42.4% at 5 minutes growing to 72.7% at 30 minutes.

Table 2

$\{|\Delta_{5r} - \Delta_{5l}| - |\varsigma_{5r} - \varsigma_{5l}|\}$ and $\{|\Delta_{30r} - \Delta 30_l| - |\varsigma_{30r} - \varsigma 30_l|\}$ Positive/Negative Value Assessments For All Subjects

Real minus Sham for Right minus Left, at 5 min and 30 min				
5 min	30 min	Yes 5 min	Yes 30 min	Yes 5 and/or 30
-1.000	2.182	0	1	1
1.364	0.818	1	1	1
-1.273	0.773	0	1	1
0.455	5.227	1	1	1
-0.273	-0.227	0	0	0
0.500	1.273	1	1	1
0.091	-0.455	1	0	1
0.409	2.273	1	1	1
1.409	-1.409	1	0	1
1.409	6.273	1	1	1
-0.318	2.045	0	1	1
0.545	3.455	1	1	1
-0.182	-2.455	0	0	0
2.455	2.500	1	1	1
3.091	0.045	1	1	1
1.409	1.182	1	1	1
-0.182	-1.727	0	0	0
1.045	1.818	1	1	1
-1.045	3.273	0	1	1
2.000	0.773	1	1	1
-0.182	-0.045	0	0	0
0.091	1.773	1	1	1
-0.682	1.000	0	1	1
2.045	2.500	1	1	1
0.591	-0.182	1	0	1
-0.682	0.500	0	1	1
0.955	1.364	1	1	1
-0.136	1.091	0	1	1
0.682	-0.955	1	0	1
0.636	0.409	1	1	1
2.773	2.227	1	1	1
1.909	0.227	1	1	1
-0.591	0.000	0	0	0
		21	24	28
Percent Response		63.636	72.727	84.848

Table 3

Real minus Sham results for the hands on the right and left sides of the body

Real minus Sham: Hands									
ID	Right minus 5 min $\Delta_{5rh} - \varsigma_{5rh}$		30 min $\Delta_{30rh} - \varsigma_{30rh}$		Left minus 5 min $\Delta_{5lh} - \varsigma_{5lh}$		30 min $\Delta_{30lh} - \varsigma_{30lh}$		Hands: Total Awards
7	-2.083	0	-4.250	0	-1.583	0	-4.167	0	0
30	-0.167	0	-1.000	0	-3.917	0	-3.583	0	0
14	-1.417	0	-5.583	0	-1.917	0	-4.250	0	0
18	-0.917	0	-1.500	0	2.583	1	2.250	1	1
19	0.583	1	1.833	1	-0.333	0	3.167	1	1
15	-0.333	0	-1.250	0	-2.750	0	2.083	1	1
1	-2.833	0	-1.667	0	1.083	1	0.167	1	1
34	-0.500	0	1.500	1	-1.167	0	0.667	1	1
31	-2.000	0	-5.667	0	1.333	1	-0.917	0	1
13	-2.750	0	-2.333	0	1.500	1	-0.833	0	1
12	2.417	1	3.917	1	4.417	1	3.167	1	1
26	-0.250	0	-0.583	0	-0.083	0	0.500	1	1
9	-0.083	0	-4.917	0	-0.750	0	-0.917	0	0
16	0.583	1	1.917	1	3.417	1	0.833	1	1
10	0.083	1	-1.583	0	-1.583	0	-1.833	0	1
3	5.083	1	4.250	1	4.000	1	5.417	1	1
22	0.333	1	-1.750	0	-0.333	0	-0.917	0	1
29	0.000	0	1.000	1	-0.750	0	0.500	1	1
21	-0.750	0	-1.417	0	-0.250	0	-4.333	0	0
8	3.250	1	1.750	1	1.583	1	0.667	1	1
20	-3.417	0	-0.500	0	-1.500	0	2.167	1	1
32	-1.083	0	2.000	1	-1.333	0	0.833	1	1
33	0.917	1	1.667	1	-0.500	0	0.750	1	1
11	-1.583	0	-1.333	0	1.333	1	2.750	1	1
6	1.000	1	-1.167	0	1.083	1	0.083	1	1
5	1.000	1	-0.917	0	-1.250	0	0.083	1	1
4	-0.250	0	1.250	1	1.750	1	2.667	1	1
28	3.333	1	3.500	1	4.750	1	4.167	1	1
27	-5.333	0	4.500	1	-2.500	0	6.583	1	1
23	0.000	0	-0.167	0	-1.083	0	1.167	1	1
25	2.000	1	0.667	1	-0.750	0	2.667	1	1
24	-0.750	0	-1.167	0	0.333	1	1.333	1	1
2	0.500	1	0.083	1	0.167	1	0.917	1	1
		13		14		14		24	28
	Percent Response	39.39		42.42		42.42		72.72	84.85

Table 4 presents the same type of data as Table 3, but for the feet rather than for the hands. The statistical analysis for our a, b, c and d expectations yield $p < 10^{-4}$ for all cases with a t statistic of 7.02, 5.49, 4.56, and 5.16, respectively. For the right foot, 60.6% of the subjects had a greater response to authentic than to sham needling at 5 minutes, which fell to 48.5% at 30 minutes. For the left foot, the same assessment gave 39.4% at 5 minutes growing to 45.5% at 30 minutes. From both Tables 3 and 4, the right hand column gives, for $(\Delta - \varsigma)$ at any value of 5 or 30 minutes and R- or L-side, that 84.85% and 93.94%, respectively, favor the authentic vs. the sham needling. For both cases, $p < 10^{-4}$ and the t-statistic are 13.39 and 22.27, respectively.

As a next to final assessment, Table 5 lists raw data for $|A_5 - A_b|$, $|A_{30} - A_b|$, $|S_5 - S_b|$, $|S_{30} - S_b|$ for both the left and right sides of the body. Looking at the total sum values at the bottom of each column, one is able to deduce that (1) $\Delta > \varsigma$ at both 5 and 30 minutes, (2) $\Delta_{30} > \Delta_5$ for both right and left sides of the body with right > left at 5 minutes but not at 30 minutes and (3) $\varsigma_{30} > \varsigma_5$ for both right and left sides of the body with right > left at 5 minutes but not at 30 minutes. Thus, the influence of both authentic and sham needling grows with time with the authentic needling providing a larger effect than the sham needling and, in both cases, the left side-effect was slightly larger than the right side at 30 minutes.

As a final assessment, the baseline "max" values were averaged for each acupuncture point with the variance and standard deviation being assessed for each patient visit individually and across all patients collectively. This result is presented in Table 6 via the following definitions [6]:

Mean Diff of Pre's = $|\sum_1^{44}$Pre 2 - $\sum_1^{44}$ Pre 1$|$ / 88, summed across all A.P.'s for one subject

Deviation = $\sum_1^{68}$ (Mean diff of pre's/68) – mean diff of pre's for that subject with 68 readings per all subjects for 2 visits at each A.P.

Dev SQ = $(\text{Deviation})^2$, across all patients

Variance = $(\sum_1^{34}(\text{Deviation})^2)/ 67$

Standard Dev = $(\text{Variance})^{1/2}$

Table 4

Real minus sham results for the feet on the right and left sides of the body

Real minus Sham: Feet									
ID	Right minus 5 min $\Delta_{5rf} - \varsigma_{5rf}$		30 min $\Delta_{30rf} - \varsigma_{30rf}$		Left minus 5 min $\Delta_{5lf} - \varsigma_{5lf}$		30 min $\Delta_{30lf} - \varsigma_{30lf}$		Total poss
7	0.5	1	1.9	1	2.3	1	-3	0	1
30	2.2	1	0.2	1	-1.7	0	-0.9	0	1
14	1.3	1	-5.6	0	-4.3	0	-4.7	0	1
18	3.4	1	5.8	1	4.2	1	-1.4	0	1
19	3	1	-2.2	0	1.3	1	-1.1	0	1
15	-2.8	0	0.3	1	3	1	-0.1	0	1
1	-0.1	0	0	0	0.2	1	2	1	1
34	0.9	1	5.5	1	0	0	-0.9	0	1
31	0.8	1	4.1	1	-1.9	0	-1.5	0	1
13	0.1	1	-4.4	0	-0.5	0	1.6	1	1
12	1.5	1	-0.9	0	-2.2	0	-4.5	0	1
26	-3.7	0	-3.6	0	-1.5	0	-4.7	0	0
9	0.4	1	-4.9	0	-0.8	0	-4.7	0	1
16	-0.8	0	0.1	1	-0.2	0	0.3	1	1
10	1.6	1	-0.3	0	-3.2	0	-0.1	0	1
3	3.5	1	3	1	1.7	1	-0.4	0	1
22	-0.4	0	-0.3	0	-0.2	0	2.1	1	1
29	0.1	1	-0.3	0	-0.3	0	0.7	1	1
21	0	0	-3.6	0	-2.9	0	-7.1	0	0
8	4.5	1	1	1	1.5	1	2.4	1	1
20	-1.6	0	2.8	1	-1.3	0	4.3	1	1
32	-1.2	0	-0.2	0	-3.1	0	0.7	1	1
33	0.2	1	-0.6	0	-0.4	0	-1.1	0	1
11	3.6	1	1.6	1	3.4	1	3	1	1
6	0	0	-1.6	0	1.2	1	-0.3	0	1
5	1.8	1	3.7	1	1.2	1	0.2	1	1
4	-1.2	0	2.7	1	-0.9	0	2.4	1	1
28	-1.1	0	-1.7	0	2.9	1	-2.7	0	1
27	-1	0	2.6	1	-2.9	0	3	1	1
23	1.8	1	4	1	1.7	1	-0.5	0	1
25	3.4	1	-0.2	0	-1.2	0	2.1	1	1
24	0.2	1	-0.6	0	-1.5	0	2.3	1	1
2	-3.1	0	1.4	1	1	1	0.4	1	1
		20		16		13		15	31
	Percent Response	60.61		48.48		39.39		45.45	93.94

Table 5

Raw Data for $|A_5 - A_b|$, $|A_{30} - A_b|$, $|S_5 - S_b|$ and $|S_{30} - S_b|$

id	Real				Fake			
	Real r-5	Real r-30	Real l-5	Real l-30	Fake r-5	Fake r-30	Fake l-5	Fake l-30
7	0.864	2.545	1.045	1.955	3.136	4.000	1.955	5.591
30	0.227	1.136	1.682	0.818	1.682	1.773	1.773	2.273
14	2.182	0.545	0.455	0.409	2.364	6.136	5.364	6.773
18	1.682	2.273	6.182	4.636	4.364	1.182	0.318	4.045
19	1.091	3.455	0.818	2.955	2.136	1.455	1.591	0.727
15	0.318	2.227	1.682	0.273	1.409	2.227	2.273	1.545
1	0.136	0.227	1.136	0.864	1.364	1.136	0.455	0.045
34	3.091	4.273	1.318	2.364	2.955	0.955	1.591	1.318
31	0.318	2.091	1.909	0.455	1.136	3.318	0.955	0.273
13	0.545	0.455	2.318	4.091	1.273	1.182	0.909	3.818
12	3.727	5.727	3.773	5.636	1.727	4.000	2.091	5.955
26	1.182	2.409	0.136	0.727	0.545	0.818	1.045	2.591
9	0.364	0.136	1.000	0.545	0.227	6.045	1.045	3.182
16	0.318	0.545	2.955	2.045	1.000	0.455	1.182	1.455
10	4.273	3.409	1.045	1.773	3.500	4.409	3.364	2.818
3	5.364	4.682	3.636	3.545	1.000	0.727	0.682	0.773
22	0.500	1.136	0.227	1.045	0.318	2.227	0.773	0.409
29	0.273	1.136	1.636	3.091	0.227	0.727	0.545	0.591
21	0.500	0.636	0.909	0.455	0.909	3.045	2.364	6.136
8	4.500	3.136	2.409	1.545	0.682	0.909	0.591	0.091
20	1.227	3.773	1.727	5.227	3.818	2.773	3.136	1.273
32	1.000	1.591	0.636	1.182	2.500	0.409	2.773	1.773
33	0.455	1.955	0.227	0.727	0.227	0.409	1.136	0.182
11	1.773	2.091	4.000	4.455	1.000	1.455	1.182	1.591
6	1.227	0.500	0.409	0.818	0.591	1.864	0.364	1.364
5	3.455	2.318	2.273	2.136	2.091	0.409	0.227	0.727
4	0.182	3.091	1.636	3.864	0.591	0.727	1.091	1.318
28	5.136	4.864	5.636	4.545	2.364	2.727	1.727	3.500
27	2.000	5.591	2.864	6.136	5.364	1.955	5.545	0.455
23	1.455	1.909	0.682	1.273	0.636	0.818	0.773	0.591
25	3.136	1.455	0.318	3.636	0.045	1.182	0.000	1.227
24	2.227	1.500	0.091	0.545	0.545	0.955	0.773	0.227
2	0.318	0.227	0.955	0.455	1.636	0.364	0.409	0.136
	55.045	73.045	57.727	74.227	53.364	62.773	50.000	64.773

Table 6

The variance and standard deviation of the baseline measurements from the MSA-21.[+]

SUBJID	Mean diff of pre's	Deviation	Dev Sq	Variance	Std Dev
7a	2.841	-0.014	0.000	11.870	3.445
7b	2.807	0.020	0.000	7.316	2.705
30a	2.682	0.145	0.021	11.498	3.391
30b	3.295	-0.469	0.220	11.325	3.365
14a	2.000	0.827	0.683	5.149	2.269
14b	2.955	-0.128	0.016	13.071	3.615
18a	2.386	0.440	0.194	15.169	3.895
18b	2.273	0.554	0.307	6.937	2.634
19a	3.602	-0.776	0.602	1.780	1.334
19b	1.761	1.065	1.135	3.878	1.969
15a	2.909	-0.083	0.007	9.738	3.121
15b	3.989	-1.162	1.350	13.576	3.685
1a	2.398	0.429	0.184	6.578	2.565
1b	1.875	0.952	0.905	4.009	2.002
34a	2.625	0.202	0.041	14.700	3.834
34b	3.580	-0.753	0.567	12.970	3.601
31a	3.670	-0.844	0.712	12.675	3.560
31b	2.852	-0.026	0.001	10.470	3.236
13a	4.659	-1.833	3.358	29.669	5.447
13b	2.852	-0.026	0.001	11.620	3.409
12a	4.250	-1.423	2.026	19.876	4.458
12b	3.784	-0.958	0.917	14.053	3.749
26a	2.807	0.020	0.000	25.707	5.070
26b	3.761	-0.935	0.874	15.061	3.881
9a	2.977	-0.151	0.023	12.450	3.528
9b	2.966	-0.139	0.019	14.864	3.855
16a	2.761	0.065	0.004	11.723	3.424
16b	2.545	0.281	0.079	7.775	2.788
10a	2.580	0.247	0.061	7.535	2.745
10b	3.636	-0.810	0.656	13.413	3.662
3a	4.500	-1.673	2.800	19.595	4.427
3b	2.205	0.622	0.387	5.486	2.342

[+]The first three columns show the differences between the pre-measurements for all patients. The 4th and 5th columns are for the variance and standard deviation within a single patient.

Table 6 continued.

SUBJID	Mean diff of pre's	Deviation	Dev Sq	Variance	Std Dev
22a	4.864	-2.037	4.150	21.788	4.668
22b	1.739	1.088	1.184	3.528	1.878
29a	3.966	-1.139	1.298	17.945	4.236
29b	2.261	0.565	0.319	7.022	2.650
21a	3.352	-0.526	0.276	11.463	3.386
21b	2.920	-0.094	0.009	10.060	3.172
8a	2.852	-0.026	0.001	10.516	3.243
8b	2.648	0.179	0.032	8.845	2.974
20a	2.352	0.474	0.225	7.402	2.721
20b	2.693	0.133	0.018	8.306	2.882
32a	2.250	0.577	0.332	8.761	2.960
32b	2.750	0.077	0.006	8.617	2.935
33a	5.057	-2.230	4.974	24.601	4.960
33b	1.773	1.054	1.111	4.237	2.058
11a	3.114	-0.287	0.082	10.434	3.230
11b	2.875	-0.048	0.002	10.426	3.229
6a	3.239	-0.412	0.170	11.828	3.439
6b	1.477	1.349	1.821	2.595	1.611
5a	2.284	0.542	0.294	8.072	2.841
5b	2.443	0.383	0.147	6.096	2.469
4a	2.761	0.065	0.004	9.677	3.111
4b	2.545	0.281	0.079	8.970	2.995
28a	4.295	-1.469	2.158	16.387	4.048
28b	3.443	-0.617	0.380	12.868	3.587
27a	2.227	0.599	0.359	6.974	2.641
27b	3.580	-0.753	0.567	13.706	3.702
23a	2.523	0.304	0.092	9.375	3.062
23b	2.455	0.372	0.138	6.493	2.548
25a	2.818	0.008	0.000	8.812	2.968
25b	2.909	-0.083	0.007	9.738	3.121
24a	3.511	-0.685	0.469	14.416	3.797
24b	2.523	0.304	0.092	7.076	2.660
2a	-0.011	2.838	8.054	0.011	0.107
2b	2.932	-0.105	0.011	11.991	3.463
	Variance		0.702		
	Std Dev		0.838		
	Average Variance			10.918	
	Average Std Dev				3.187

Discussion

Before proceeding to a rigorous discussion of Tables 1 to 6, it seems beneficial to look at the fundamentals of the measurement process itself. This will allow us to see if the "max" column from Figure 1 is, in fact, the best single choice for assessment of the MSA-21 capabilities. Further, it will allow us to relate these different columns to fundamental parameters and processes operating in the body. Before proceeding, we must recognize that what we call a physical material (e.g. skin) is comprised of three main aspects, (1) the coarse physical (particulate), (2) the fine physical (information wave) and (3) a higher dimensional "coupling" medium[1]. Here, we will restrict ourselves primarily to the coarse physical aspect and only indicate where and how a contribution from the fine physical aspect can be seen. The full picture is well beyond the scope of this paper.

The MSA-21 measurement system is based on an earlier instrument, the Voll Dermatron[5], which applies a fixed voltage, Vo, to an A.P., measures the relatively slow time-dependent current response, i (t), and internally calculates (and displays) the time-dependent electrical impedance, Z(t). Ohm's law provides us with the simple formula

$$Z(t) = V_o/i(t) \qquad (1a)$$

The idealized electrical equivalent circuit for skin is shown in Figure 2a, where R_1 is the resistance of the dermis while R_2 and C are the resistance and capacitance, respectively of the epidermis (especially dominant is the stratum corneum)[7,8]. For such a circuit, a constant applied voltage, V_o, yields a current profile like that shown in Figure 2b, where the current falls from the initial value, i_o, in an exponential fashion (with time constant, τ), to a final value at long time ($\Delta t \sim 3\tau$) of i_∞. Theory[7] yields the following:

$$i_o = V_o/R_1 \; ; \; i_\infty = V_o/(R_1 + R_2); \; \tau = R_1R_2C/(R_1+R_2) \approx R_1C \text{ for } R_1 << R_2 \qquad (1b)$$

Thus, from eqns 1a and 1b, we see that the initial impedance, $Z_o = R_1$, at t=0, and that Z should rise exponentially with a time constant, τ, to a final value of $Z_\infty = R_1 + R_2$ so that

$$Z(t) \approx R_1 + R_2(1 - e^{-t/\tau}) \qquad (1c)$$

This would be the result if R_1, R_2 and C for the skin did not change as a result of this slow conduction of ions between the cells of the epidermis and the polarization of the ions within each such cell.

For constant material parameters then, one expects a plot of Z vs. time to be like that shown in Figure 3a, whereas the MSA-21 yields plots like that shown in Figure 2b. Large electrode area studies conform to Figure 3a [8] where $R_2 \sim 3\text{-}5\ R_1$ and $\tau \sim 10^2$ seconds (R_1 and R_2, measured, include contact resistance between the electrode and the skin).

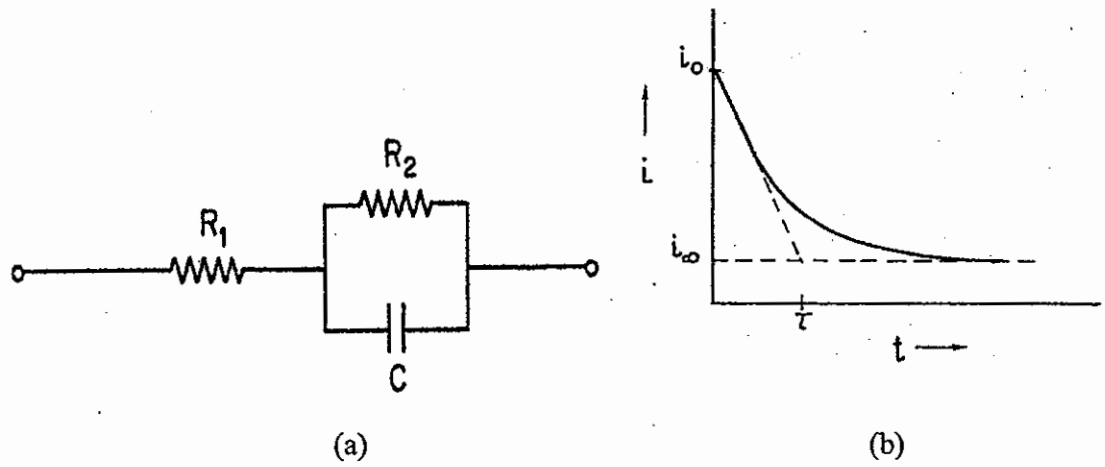

Figure 2

(a) The simplest frequency independent electrical equivalent circuit used for skin measurements.
(b) Current waveform arising from the application of a constant DC voltage to the circuit of Fig. 2a.

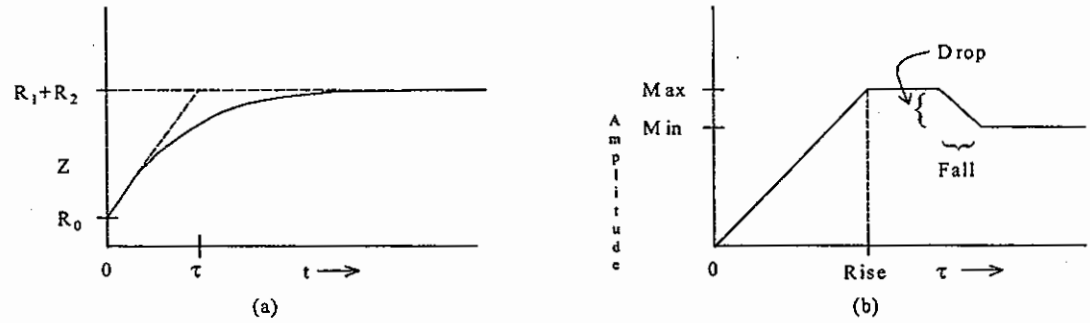

Figure 3

(a) Solid curve is the expected change in Z with time while (b) shows the MSA-21 actual plot with time.

Perhaps, since the MSA-21 measuring electrode is small, it contacts largely the high conductance region of an acupuncture meridian so that R_1 and R_2 can be smaller (by a factor of ~ 10) than the values found for Figure 2a (and also depend upon the hypnogogic state of the subject[10]). This suggests that the time-plot of Figure 2b would appear to go through the origin rather than giving a measurable intercept. Perhaps also, the internal electronics of the MSA-21 linearize the exponential curve of Figure 2a to follow the dashed line to the intercept point with R_1+R_2 and τ, respectively, for the particular acupuncture point/meridian circuit element. However, there is no possibility for this idealized electrical equivalent circuit (see Figure 2a) to account for min, drop and fall.

To effectively bring min, drop and fall into the picture, we must include a contribution from the "fine physical" aspect of the body and postulate that the A.P.s and meridians function at that level and that Qi-flow induces an electric field, E, along the meridian trace at the coarse physical level[7]. This is why the conductance of an A.P. is measured to be so much higher than non-A.P. skin. Conversely, if a current is driven along a meridian by an applied voltage, V_o, at the coarse physical level, this will induce a magnetic vector potential differential build-up at the fine physical level which will eventually discharge back into the coarse physical level as an increased pulse of current flow once ?approaches ?$_\infty$ (and therefore a reduced Z as detected experimentally). Thus, max-min = drop, would be this ΔZ change and fall would be its effective pulse time. Now we can properly proceed because some of the mystery has been taken out of the measurement system.

Overall we have used "max" as our measurement parameter for testing, which simple theory suggests is ~R_2, for the epidermal conduction process. Likewise, we could have used τ as our testing parameter and evaluated R_1C for the various subjects. Further, (1) if the theoretical analysis is correct, the measurement parameter "drop" should be ~0 for sham acupuncture at all A.P.s for all subjects and (2) for healthy subjects such as these, the direction of Qi-flow through the body would induce a bucking E-field (smaller ?and larger Z) on one side of the body and an enhancing E-field (larger ?and smaller Z) on the other. Table 2 suggests that such an additional field effect exists with the L-side being the bucking side and the R-side being the enhancing side.

For healthy subjects, any $(\Delta\text{-}\varsigma)>0$ at either 5 minutes, 30 minutes, R-side or L-side, confirms our hypothesis concerning authentic vs. sham acupuncture. The far right column of Tables 1 and 2 robustly supports this hypotheses indicating that the MSA-21 instrument can discriminate authentic from sham acupuncture needling. Table 1 suggests that 5 minutes post-needling was insufficient time to see a meaningful effect, whereas 30 minutes was sufficient. Perhaps 60 minutes post-needling would have shown and even larger effect.

It is interesting that, from Table 3, $(\Delta\text{-}\varsigma)_h>0$ for both 5 min and 30 min at the R-side and the L-side of the body was not generally satisfied at least 50% of the time. This suggests that, indeed, it is important to take absolute values rather than algebraic values for such quantities. Likewise, for Table 4, the same unsatisfactory position holds for $(\Delta\text{-}\varsigma)_f>0$ when the algebraic values are used for the feet. By simply glancing at Tables 3 and 4, one readily sees that the absolute values of these quantities readily satisfy expectations for both the hands and the feet.

The final assessable question for the MSA-21 is "are repeated measurements by this instrument within an acceptable range of accuracy?" Table 6 shows that the variance and standard deviation, respectively, are 0.70 and 0.84 across all subjects for the difference between the pre-needling measurements at all A.P.s over two visits per subject. Most people would consider this to be acceptable reproducibility for this type of measurement. However, it is very important to stress that all the measurements were made by a long-time, accomplished practitioner and not by a novice.

Conclusions

1. The MSA-21 instrument was readily able to distinguish authentic acupuncture needling from sham acupuncture needling and

2. For healthy subjects, the MSA-21 instrument detected a larger response to authentic needling compared to sham needling on the right side of the body relative to the left. This body asymmetry effect could be related to the direction of Qi-flow through the body.

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Appendix A

The report shown below is for the first of four data sets taken for the first visit of this subject. A complete data set would consist of eight such data sets, 2 pre-measurements, post 5 and post 30 minutes for both sessions (Real and Sham).

3/1/2002 11:22:55 AM Page 1

Clinic	Shealy Wellness Center	Phone	4804713321
		Fax	
Address	1610 E. Evergreen	Email Address	nrizzo@mayo.edu
		Internet Address	
City	Springfield		
State or Province	Mo		
Zip or Postal Code	85255		
Country	us		

Confidential Client Information

Client Number	1A	Visit Number	1
Name	Shealy, Norm	Date and Time	6/22/2001 10:07:15 AM
		User Name	SYSDBA

Base Readings

Point ID	Meridian	Max	Min	Rise	Fall	Drop
LY-1-2*R	Lymphatics	50	49	38	0	1
LU-10c*R	Lungs	50	50	33	0	0
LI-1b*R	Large Intestine	50	50	32	0	0
NE-1b*R	Nervous System	53	52	50	0	1
CI-8d*R	Circulation	57	57	61	0	0
AL-1R	Allergies	48	47	30	0	1
AL-1b*R	Allergies	49	49	31	0	0
OR-1b*R	Cellular Metabolism	49	49	22	0	0
TW-1R	Endocrine System	51	50	34	0	1
TW-1b*R	Endocrine System	51	50	52	0	1
HE-8c*R	Heart	52	52	39	0	0
SI-1b*R	Small Intestine	50	50	39	0	0
LY-1-2*L	Lymphatics	49	49	25	0	0
LU-10c*L	Lungs	50	49	35	0	1
LI-1b*L	Large Intestine	50	49	36	0	1
NE-1b*L	Nervous System	56	56	42	0	0
CI-8d*L	Circulation	47	47	38	0	0
AL-1L	Allergies	47	47	41	0	0
AL-1b*L	Allergies	48	48	44	0	0
OR-1b*L	Cellular Metabolism	48	48	26	0	0
TW-1L	Endocrine System	48	48	38	0	0
TW-1b*L	Endocrine System	48	48	34	0	0
HE-8c*L	Heart	50	50	37	0	0
SI-1b*L	Small Intestine	50	50	47	0	0
PA-1a*R	Pancreas	65	65	32	0	0
LV-1a*R	Liver	53	53	36	0	0
JO-1b*R	Joints	50	50	30	0	0
ST-44b*R	Stomach	56	56	37	0	0
FI-1b*R	Connective Tissues	51	51	36	0	0
SK-1-3*R	Skin	51	51	35	0	0
FA-1b*R	Fatty Tissues	53	53	65	0	0
GB-43b*R	Gallbladder	51	51	32	0	0
KI-1-3*R	Kidneys	51	51	37	0	0
UB-65R	Urinary Bladder	47	47	29	0	0
SP-1a*L	Spleen	53	53	29	0	0
LV-1a*L	Liver	60	60	37	0	0
JO-1b*L	Joints	54	54	40	0	0

Weakened Balanced Stressed

Confidential Client Information

Client Number	1A	Visit Number	1
Name	Shealy, Norm	Date and Time	6/22/2001 10:07:15 AM
		User Name	SYSDBA

Base Readings

Point ID	Meridian	Max	Min	Rise	Fall	Drop
ST-44b*L	Stomach	54	54	37	0	0
FI-1b*L	Connective Tissues	53	53	29	0	0
SK-1-3*L	Skin	51	51	23	0	0
FA-1b*L	Fatty Tissues	51	51	25	0	0
GB-43b*L	Gallbladder	50	50	24	0	0
KI-1-3*L	Kidneys	55	53	64	16	2
UB-65L	Urinary Bladder	51	51	35	0	0