The Daily Variance in Impedance at Acupuncture Points

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ABSTRACT

Background: Low electrical impedance at acupoints is a familiar concept, and it has also been found that this increases with poor organ function. Kovich hypothesizes that organ states are communicated to their related acupoints in real time, and this experiment set out to test this.

Methods: The electrical impedance at 4 digestion-related acupuncture points (acupoints) was recorded over a 14-hour period and a food diary was recorded. The readings were taken in 23 sessions, between which the participant continued his usual daily routine.

Results: The impedance at all the monitored acupoints varied considerably throughout the day, and the peaks were aligned with periods of high stomach activity.

Conclusion: Variations in stomach function produced corresponding variations in the impedance at key stomach-related acupoints. However, the experiment was limited in that samples were only taken at around 30-minute intervals, and further investigations are needed to explore this phenomenon in more detail.

Introduction

The phenomenon of low electrical impedance at acupoints has been widely studied since the 1950’s, with Voll (1953)[1], Nakatoni (1956)[2], and Niboyet (1957)[3] pioneering this work. And the low impedance has also been found to decrease further at acupuncture points (acupoints) whose associated organ is diseased. In 1978, Serisawa [4] found that in 50 patients with pulmonary tuberculosis, points of reduced impedance existed along the lung meridian on the upper arm. In 1980, Oleson et al [5] found that in a study of 40 patients, areas of reduced impedance at auricular acupoints could be used to diagnose musculoskeletal pain (75.2% accuracy). In 1981, Rosenblatt [6] found that acute physiological changes in heart rate were reflected in acute changes in impedance at acupoints associated with the heart, while no change in impedance at another acupuncture nearby and a non-acupoint occurred. In 1985, Sullivan et al [7] found that in lung cancer patients, there was a change in the impedance at the acupoints Lung-10 (Yijii) and Lung-11 (Shaoshang) when compared to patients with healthy lung function. In 1993, Saku et al [8] found that in patients with acute myocardial infarction, there was significantly reduced impedance at the auricular cardiac acupoint in 28 out of 30 patients (compared to only 2 out of 19 patients in the control group). These findings suggest that when an organ’s function is weak, this is reflected in reduced impedance at its related acupoints.

In 2016, Kovich [9] hypothesized that there is real-time communication between each organ and its associated meridian and acupoints via an electrical wave, and that the local effects at acupoints (such as redness, rough skin, boils, the tenderness felt at acupoints when the associated organ is functioning poorly, and also the impedance and skin temperature) are produced by the associated organ’s real-time influence on those locations. This suggests that such qualities as the impedance at acupoints ought to constantly vary to reflect the real-time state of an organ’s function. To test this, the impedance at several stomach-related acupoints was monitored throughout the day to determine if there was any variance, and whether this correlated with the stomach’s varying function.

Materials and Methods

Measuring skin impedance is challenging. In a 2008 review by Ahn et al [10], 9 studies were summarized that investigated the phenomenon of lowered impedance at acupoints, and only 5 of the 9 studies managed to confirm the phenomenon. Due to the
challenges involved, it was necessary to first explore the literature to identify the most reliable techniques, and to then experiment further to develop the methods, equipment and techniques used in this experiment. Acupoints were monitored on the right lower leg: Stomach-36 (Zusanli), Stomach-37 (Shangjuxu), Stomach-39 (Xiajuxu), and Gallbladder-34 (Yanglingquan). A control point was also monitored, 21 mm from each acupoint, diagonally in a lateral/distal direction, except for the GB-34 control, which was in a medial/distal direction.

Each acupoint was first located by a Chinese Medicine acupuncturist with over 12 years clinical experience and this location was then verified electrically, and the point of lowest impedance identified. This location was usually within 4 mm of the point located by the practitioner. The electrically-located acupoint was then marked with a felt-tip pen so that throughout the day, the test electrode could be replaced within around 1 mm of the same location.

The test electrode consisted of a pair of electrodes, 6 mm apart, each having a conical point, reducing to a tip of around 1 mm diameter. An earth electrode (consisting of a standard ECG electrode) was also connected at about 4-10 cm from each test acupoint. Gel was used to optimise the contact between each electrode and the skin. A PicoScope 2204A was used to generate a 400 mV 5 kHz sine wave signal, which was passed through a simple voltage divider circuit, into each test electrode and returned via the earth electrode. A Proster VC99 digital voltage meter was used to read the RMS voltage at each test electrode. These voltages were recorded on a spreadsheet and later converted to peak values and then into kΩ.

Fig. 1 shows the proximity of the acupoints near to ST-36 on Participant A, with the relative distances marked in blue. The test electrode was being held on the control point for ST-37. After a reading was taken, this same test electrode was then moved to the next acupoint to take its reading.

The Appendix I lists an accompanying document that describes in detail the equipment used, how to construct the test electrodes (which were custom built), and the techniques used to reliably locate acupoints electrically.

Participant A

Participant A was a 57-year-old male with poor stomach and pancreas function (usually known as “Spleen chi deficiency” in Chinese Medicine; and comparable terms would be used in Traditional Korean Medicine, and in other holistic disciplines). He had a poor sense of taste, mild intolerance to certain foods, his stools sometimes tended towards softness; he bruised easily, and after eating a large meal, he frequently belched. He was a heavy thinker and found it harder to think as the day progressed, he could usually only think clearly up to around midday. He also experienced soreness along the gallbladder meridian on the outside of his right lower leg, which coincided with periods of heavy thinking.

Voltage readings were taken in 23 sessions, over a 14-hour period on the same day (18 Feb 2018), between 08:00 and 22:00. In between the sessions, the participant continued his usual daily routine. His work involved digesting information, making decisions, and some creative thinking. The voltage readings were taken while he was sat relaxed in a chair. The room temperature was around 22 C throughout. On the day, the following events were noted.

08:22: He had a bowel movement.
08:50: He ate a large portion of porridge, followed by mild exercise.
10:50: He ate a large snack (2 pieces of toast and a chocolate muffin) with hot tea.
13:30: He ate his main meal with hot tea, followed by exercise outdoors.
17:00: He was notably hungry, since he would normally have taken a snack at this time, but he put off eating because he was working.
18:20: He ate a large snack, with hot tea.
19:10: He had a 40-minute walk outdoors.
20:15: He ate a chocolate muffin, with hot tea.

Participant B

Only a single main participant was used in the experiment, since the objective was not to test skin impedance between different people, but only to measure the daily variance on the same person. However, the experiment was repeated on a 2nd participant, to verify that the observed phenomena were not peculiar to a single person.

Participant B was a male, aged 34, who also had poor stomach and pancreas function (the majority of people in developed countries tend to have poor pancreas function, since its usual cause, according to Chinese Medicine, is overthinking). However, the participant lived a less regulated life than Participant A. He often worked night shifts, rarely ate breakfast, and often slept late on his days off. On the day of the experiment (21st Feb 2018), the following events were noted.

11:30: He ate 3 cherry tomatoes, which was the 1st food he ate on that day.
11:54: He ate 1 piece of bread with chocolate spread.
13:30: He ate a large meal.
15:00: He arrived back, after a 40-minute walk outdoors.
17:30: He started to feel hungry.
19:20: He ate a large meal.
21:00: He ate a bowl of popcorn.

Voltage readings were taken in 20 sessions, over a 13-hour
period on the same day. The participant was lying on a couch during each session, and the room temperature was around 22 C throughout. Between the sessions, the participant continued his usual daily routine.

**Results and Discussion**

The experimental data is available in an online dataset [11] which includes all RMS millivolt readings from each electrode, and the calculations used to convert these readings into kΩ and to produce the gradient figures. Also included is the Matlab scripts which were used to produce the charts; supplemental charts that are not given here; and also copies of the data in Matlab tables [11].

**Participant A**

**Stomach-36 readings**

Fig. 2 shows a plot of the readings taken at right ST-36, its control point, and the impedance gradient. A fixed pair of electrodes, 6 mm apart, was used to take each reading. The "gradient" figures represent the difference in impedance between the 2 electrodes. In other words, how steeply the impedance reduced over this 6 mm distance, to the centre of the acupoint.

Since it has often been noted that the impedance of an acupoint tends to reduce when the function of its related organ is weak (i.e. when that organ is diseased, or simply exhausted), it could be considered that an acupoint's impedance is proportional to the strength of its related organ's functioning. The peaks in Fig. 2 follow this pattern. The participant ate a large breakfast at 8:50 AM, which corresponds with the 1st peak; then he ate a large snack at 10:50 AM, which produced the next peak; then he ate his main meal at 13:30, which produced the largest peak. Following this, the deepest trough occurred. This may reflect the fact that the participant had poor stomach function, and the work of digesting this large meal, weakened his stomach function. The next significant peak came at around 17:00, which is when he would habitually take an evening snack. At this time, he was notably hungry but, because he was still working, he put off eating until 18:20, when the next notable peak occurred in Fig. 2.

Readings were taken at around 30-minute intervals. This explains why some of the peaks do not line up exactly with the associated events. For example, the participant ate breakfast at around 8:50, but readings were taken at 8:30 and 9:09 [11], which means that the “breakfast” peak occurs on the chart at 8:30 (the time of the reading), rather than at 8:50. If a reading had been taken at 8:50 AM, the peak may well have been higher.

It is also noted that the 1st peak on Fig. 2 begins to rise before the participant ate breakfast, implying that the stomach function increases before eating. This anticipation could be accounted for by hunger (which is probably associated with the stomach, if not a function of it), and possibly contributed to by the participant's anticipation of eating.

The impedance gradient also seems to follow a meaningful pattern. This is a measure of how steeply the impedance falls between the 6 mm radius and the acupoint's centre. One possible interpretation of this value is that it may correspond to the degree of an organ's stress. If this interpretation is applied, the gradient readings seem to make sense. In Fig. 2, the gradient peaks tend to correspond with the impedance peaks. And digesting the main meal at around 13:30 produced the 1st large peak. From this point onwards, the gradient peaks tend to occupy a larger portion of the “function” peaks, and from 19:00 onwards to be much greater than the function peaks. This suggests that from around 14:00, the stomach finds it harder to function as the day progresses.

**Chinese medicine interpretation**

In Chinese Medicine it is recognised that the strength of an organ's function follows a 24-hour cycle [12]. Stomach function is thought to peak between the hours of 07:00 and 09:00 (and the pancreas, which works closely with the stomach in digestion, peaks between the hours of 09:00 and 11:00). This tendency would be exaggerated in the participant, since he had weak stomach and pancreas function. This explains his tendency to belch after his main meal, when, from Fig. 2, it can be seen that his stomach function dips to its lowest value.

In Chinese Medicine it is also recognised that the abdominal organs play a part in producing a person's thoughts and emotions [13]. For example, patients with weak stomach and pancreas function would usually find it harder to think clearly after midday (just as the participant does), and when they indulge in heavy bouts of thinking, this would usually produce a flair up of their signs and symptoms related to weak stomach and pancreas function, such as loose stools, abdominal bloating, food intolerances and reduced sense of taste.

This pattern appears to be reflected in Fig. 2. Though the participant did not eat another large meal after 14:00, he continued to think and study hard, which may account for the wide peak at 20:00, and for the stress of his stomach, which was then far greater than when digesting his main meal at around 13:30. The stress was then so much greater, because the stomach function was now much weaker, even though he was continuing to “digest” thoughts.

Admittedly, these latter interpretations rely on Chinese Medicine knowledge, which is a specialist area; however, they do provide an explanation for the experimental data.

**The control readings**

The control readings in Fig. 2, roughly follow the impedance of ST-36 until around 12:00, but then become notably out of sync, until around 17:00. However, when comparing the ST-36 readings with the control readings, t(22) = 0.75, p = 0.463 using Cronbach α = 0.05, it is not possible to reject the hypothesis that there is no difference between the ST-36 readings and those taken nearby.

However, all the control points were situated only 21 mm from their respective acupoints. Hence, it might be expected that each
acupoint’s influence may extend to these control points, but perhaps to a reducing amount with distance; and this pattern can be seen in some parts of the charts for each of the test acupoints, while in other parts of the same charts there is less synchronicity.

When comparing the ST-36 readings with those taken at the 3 nearest locations (see Fig. 1), and instead using those as control points for ST-36 the level of statistical significance was tested.

- GB-34 ctrl (30 mm away from ST-36), t(22) = 3.35, \( p = 0.003 \)
- GB-34 (48 mm away), t(22) = 2.87, \( p = 0.009 \)
- ST-37 (62 mm away), t(22) = 2.62, \( p = 0.016 \)

Using these alternative control points, it is now possible to accept the hypothesis that the ST-36 readings are significantly different to those taken at any of these 3 nearby locations. This supports the notion that the readings taken at ST-36 do reflect the function of the stomach, rather than a pattern of skin impedance that might occur in that region, regardless of organ function.

**Stomach-37 readings**

Fig. 3. shows plots of the readings taken from right ST-37. Even though this acupoint is on the stomach meridian, it is said to also heavily influence the large intestine [14]. In other words, the large intestine function would also be reflected to this acupoint, as well as some aspects of the stomach function. At 08:22, the participant had his only bowel movement of the day, and at around this time, Fig. 3 shows the highest peak of impedance at ST-37.

The other notable feature in the chart is the greatly increased stress from around 15:00 onwards, accompanied by peaks of stomach activity that are roughly in sync with those shown at ST-36. This increased stress could be accounted for in the same way that it was for the ST-36 readings.

**Stomach-39 readings**

Even though this acupoint is on the stomach meridian, it is said to also heavily influence the small intestine [15]. In other words, the small intestine function would also be reflected to this acupoint, as well as some aspects of the stomach function.

The small intestine extracts nutrients from digested food, after the stomach, pancreas and gallbladder have begun the digestion. In Fig. 4, the peaks tend to roughly coincide with those in Fig. 2, but sometimes occurring slightly later (which would be expected, since the small intestine’s role lags that of the stomach). Apart from this, the pattern in the gradient is also similar to that in Fig. 2, with higher peaks from 16:00 onwards.

The observations regarding the control readings of ST-36, also apply to those of ST-39.

**Gallbladder-34 readings**

The gallbladder releases bile into the duodenum (the tract through which food exits the stomach, which is regarded as the start of the small intestine) to assist in the digestion of fats.

It could be said that each of the 3 previous charts (for ST-36, ST-37, and ST-39), relate to different aspects of digestion. Hence there is some agreement in the locations of some of their peaks, but some places where they clearly differ. Up until around 16:00, the GB-34 peaks also coincide with those in the ST-36 chart, but the GB-34 peaks tend to lag by about 10–30 minutes (such as the peaks at around 11:30 and 13:30). This would be expected, since the gallbladder processing follows that of the stomach. However, due to the readings being taken at around 30-minute intervals, it is not possible to place the peaks accurately.
The feature that most stands out is in the gradient readings. Throughout the test period, the gallbladder appears to be the most consistently stressed organ. Again, Chinese Medicine knowledge provides a possible explanation for this. For over 2,000 years, it has been recognised that the gallbladder plays a large part in enabling people to make decisions. And this connection is often observed in clinic today, where, in patients whose work involves heavy decision making, the key gallbladder acupoints (such as GB-34) will often be notably tender when pressed. Indeed, Participant A even reports that the outside of his lower right leg (along the gallbladder meridian) often feels sore after periods of thinking heavily and making constant decisions. And the participant’s tendency to heavily think throughout the day would also explain the stress detected in his gallbladder.

**Participant B**

Fig. 6 and Fig. 7 show plots of the readings taken at right ST-36 and GB-34. No control readings were taken, since the objective was merely to compare the impedance readings with those of Participant A.

The notable feature of the ST-36 chart is that every peak coincides with instances of the participant either eating or feeling hungry. The largest peak coincides with eating the largest meal. And even when he snacked on a bowl of popcorn at 21:00, this produced a clear peak. The other notable feature is the high degree of stress that his stomach felt throughout (the gradient readings). This could perhaps be accounted for by the fact that his lifestyle was so irregular, particularly changing between nightshifts and dayshifts, which may stress all his organs.

The GB-34 chart generally follows the stomach activity, as would be expected. The participant was also a heavy thinker, who often wrestles with choices in life, and this may explain some of the gallbladder peaks, and perhaps the large peak in gallbladder stress at 18:00.

**Conclusion**

The ST-36 charts for both participants follow different patterns, and those patterns reflect the variations in stomach function in each participant. This strongly suggests that the variations in organ function are reflected in the impedance at key acupoints along the organ’s related meridian, and that the process takes place in real time. The charts for the skin impedance at ST-36 and ST-37 on Participant A show a notably different pattern between 08:00 and 15:00, and overall, the skin impedance between ST-36 and ST-37 was significantly different ($t(22) = 2.62, p = 0.016$). These are consecutive acupoints on the same meridian and are only 6.2 cm apart (on this participant). The pattern of skin impedance for ST-36 and ST-37 appears to reflect different aspects of stomach function (the 2nd acupoint appearing to reflect the stomach’s functional relationship with the large intestine). The fact that these 2 acupoints are so geographically close, yet display a different, real-time impedance pattern, further supports the notion that this impedance reflects the related organ’s function, rather than being due to any general pattern in the skin impedance locally.

The results in this study are consistent with Kovichi’s hypothesis that organ states are communicated to the organ’s associated acupoints in real time. However, the results do not indicate the speed of this communication, only that it takes place. The study was limited in that readings were taken at around 30-minute intervals. Similar studies, with real-time sampling (taking many samples per second), would be useful to provide much greater detail of the variation in acupoint impedance, and possibly indicate the speed of the communication.

**Conflicts of Interests**

The author received no financial contribution towards the design or conducting of this research, nor towards the preparation of this article.

**References**


**Appendix 1.**

Accompanying documentation, which can be downloaded free of charge:

The above document describes in detail the equipment used, the design philosophy, how to construct the electrodes (since these were custom built), and the techniques used to reliably locate acupoints electrically.