



## Pilot Study

# Changes of skin electrical potential in acupoints from *Ren Mai* and *Du Mai* conduits during *Qigong* practice: Documentation of a clinical phenomenon

Luís Carlos Matos<sup>a,\*</sup>, Jorge Machado<sup>b,e</sup>, Henry Johannes Greten<sup>b,c,d</sup>,  
Fernando Jorge Monteiro<sup>a</sup>

<sup>a</sup> Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias s/n, 4200-465, Porto, Portugal

<sup>b</sup> ICBAS – Institute of Biomedical Sciences, University of Porto, 4099-030, Porto, Portugal

<sup>c</sup> DGTCM – German Society of Traditional Chinese Medicine, 69126, Heidelberg, Germany

<sup>d</sup> HSCM – Heidelberg School of Chinese Medicine, 69126, Heidelberg, Germany

<sup>e</sup> LABIOMEPE – Biomechanics Laboratory of Porto, University of Porto, 4200-450, Porto, Portugal

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## ABSTRACT

*Qigong* is a therapeutic method of traditional Chinese medicine (TCM) that combines slow, soft movements and postures with breath control and a special mental state of 'awareness'. TCM holds that the practice of *Qigong* promotes the 'circulation of *qi*' in the human body, the 'flow' of upward *yang qi* and downward *yin qi* to establish 'balance'. In Western terms, this may be generally equivalent to vegetative homeostasis and the emotionally balanced state induced thereby. Researchers have often attempted to evaluate the functional movements of *qi* using measurements of the skin's electrical resistance. However, these methodologies have proven difficult to gauge, validate, repeat, and interpret. We aimed to overcome these limitations by measuring the skin's electrical potential between two points of the same system. The main goal of this study was to assess the skin's electrical potential changes in acupoints from the *Ren Mai* and *Du Mai* conduits, or meridians, as well as in other points of interest, during *Qigong* practice. While participants performed a specific *Qigong* exercise called 'White Ball', we observed significant changes in the skin electrical potential on *Mingmén* (GV 4), *Shèndào* (GV 11) and *Baihuì* (GV 20), from the *Du Mai* conduit, as well as on *Huiyin* (CV 1), *Qihai* (CV 6), *Zhongwan* (CV 12) and *Danzhong* (CV 17), from *Ren Mai*. These observations are in accordance with TCM theory and may contribute to the explanation of the vegetative physiological changes that are associated with '*qi* flow' in TCM.

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## 1. Introduction

*Qigong* is a traditional vegetative biofeedback therapy used in Chinese Medicine. It comprises concentrated motion and postures combined with breathing exercises (Matos et al., 2015; Chen and Liu, 2010). The '*qi* activation' is achieved with breath control and a special mental state of 'awareness' (Greten 2009, 2013; Enz, 2011; Posadzki, 2010; Jahnke et al., 2010). TCM holds that the *qi* itself cannot be seen and is intangible, whereas the effects of *qi* may be seen in the functional so-called organ patterns, which include functional changes of the conduits or 'meridians'. Thus, the practice

of *Qigong* promotes the 'circulation of *qi*' in the human body, the 'flow' of upward *yang qi* and downward *yin qi* to establish 'balance,' thereby improving and strengthening overall well-being and homeostasis (Zeng et al., 2014; Song et al., 2017; Zou et al., 2017). From a Western standpoint, these exercises may be understood as vegetative feedback promoters in which *yin*, *yang* and the Phases are cybernetic elements of a circular process of physiological regulation. This process is governed by transmitters and neuronal pathways, where sympathetic functions are more active in *yang* phases and parasympathetic (vagal) activity is more present in *yin* phases (Greten, 2008a; Galantino and Muscatello, 2011).

The Heidelberg model of TCM, which is a model of vegetative system biology (Greten, 2008b; Sertel et al., 2010), sees strong analogies between the effects of *xue* ('blood'), as described by the classical texts and the clinical effects of microcirculation in Western

\* Corresponding author.

E-mail address: [lcmatos@fe.up.pt](mailto:lcmatos@fe.up.pt) (L.C. Matos).

medicine. Moreover, the classical theoretical foundations of TCM dictate that intention (*yi*) directs the movement of *qi*, which in turn directs the flow of *xue* in the body (Sancier and Holman, 2004; Johnson et al., 2000). Imagination and intention; that is, focused thinking, which have been studied for the hypothetical ability to exert effects on physical reality (Radin et al., 2015; Matos et al., 2017), are viewed as capacities of *Shen* (mind), which rules, limits, and controls emotions and associations in order to create a mental and emotional state called presence; an ideal, balanced state of mind (Greten, 2008a; Ai, 2011).

As shown by Matos et al. (2012), in a study that assessed *Qigong*-related effects using infrared thermography, an increase in the fingers' temperature associated with an increase of microcirculation was observed during the practice of a special system of *Qigong* known as 'White Ball'. During the experiments, temperature changes were detected only when the subjects felt the subjective *qi* sensation that results from the combined action of imagination and awareness (see Fig. 1). *Qi* sensations during *Qigong* practice, also known as *Ba Chu* or 'Eight Touches', are well described and may include pain, itching, cold, warmth, lightness, heaviness, astringency and slipperiness (Xu, 1994; Yang, 2016; Chen and Liu, 2010).

In fact, during preliminary control interventions in which the same physical posture was adopted, but without the mental attitude and imagination associated with *Qigong*, no vegetative activation or temperature changes were observed (Matos et al., 2012). These results corroborate the thesis that the 'mind' activates the *qi*, which itself moves the *xue*.

Blood flow perfusion, fluid balance and accumulation and dispersal of substances may be related to increased or decreased electrical activity in specific areas of the body (Sancier and Holman, 2004; Jin et al., 2017; Trivedi et al., 2013). Moreover, unique locations on the body's surface at which the skin's electrical conductance, capacitance and potential are higher compared with neighbouring spots, have often been found to coincide with the classical acupoints (Comunetti et al., 1995; Pérez Samartín, 2011; Ahn et al., 2008; Litscher et al., 2011; Cassidy, 2002). It has also been claimed that between two points along the same conduit, electrical conductance is greater than it is between points not sharing this relationship, suggesting that acupuncture structures constitute special pathways for electrical signals (Cassidy, 2002).

Electrodermal screening techniques have been used for decades, not only for point location, but also for diagnostic and therapeutic purposes (Colbert et al., 2011). These devices and approaches vary in terms of instrumentation and the parameters they measure, such as electrical resistance, impedance and potential, as well as in terms of the number and type of acupoints they use. However, all of them are based on the principle that acupoints have unique electrical properties (Ahn and Martinsen, 2007). Electroacupuncture according to Voll (EAV), the Ryodoraku mechanism, and similar techniques, are based on the measurement of electrical resistance (or its inverse quantity, electrical conductance), and have been reported to aid in the diagnosis of certain pathologies (Lee et al., 2010a; Tseng et al., 2014; Weng et al., 2004). Nevertheless, due to the lack of methodological standards and reporting protocols, most of the findings in this research field are difficult to replicate or even to evaluate critically (Colbert et al., 2011). In fact, several factors, such as the use of alternating or direct current stimulation; electrode polarisation; the stratum corneum impedance; the presence of sweat glands and skin moisture; the contact medium and electrode geometry; and the pressure, angle, and duration of electrode probe application may contribute to the final electrodermal reading. The presence of such factors has raised doubts about the validity of these devices (Colbert et al., 2009; Ahn and Martinsen, 2007).

The electrical potential of an acupoint is a relative quantity that measures how much energy capacity it possesses as compared to a reference (Ahn and Martinsen, 2007). It is a measurement commonly used to study bioelectricity related to low-level endogenous currents and has been shown to enable the assessment of functional effects and particularities in acupoints as well as along conduits (Lee et al., 2005; Kim et al., 2013; Xu et al., 2015; Ahn and Martinsen, 2007). The properties of acupoints may be altered by different stimuli, which induce physiological alterations and shifts in the endogenous electrical potential and current in the tissue (Pontarollo et al., 2010; Kim et al., 2013; Xu et al., 2015; Gow et al., 2012; Lee et al., 2010b). Acupuncture and *Qigong* studies that simply measure the electrical potential difference between two points of the same system without any external electrical load, may overcome or at least minimise the aforementioned limitations of electrodermal readings. Moreover, the measured signals are

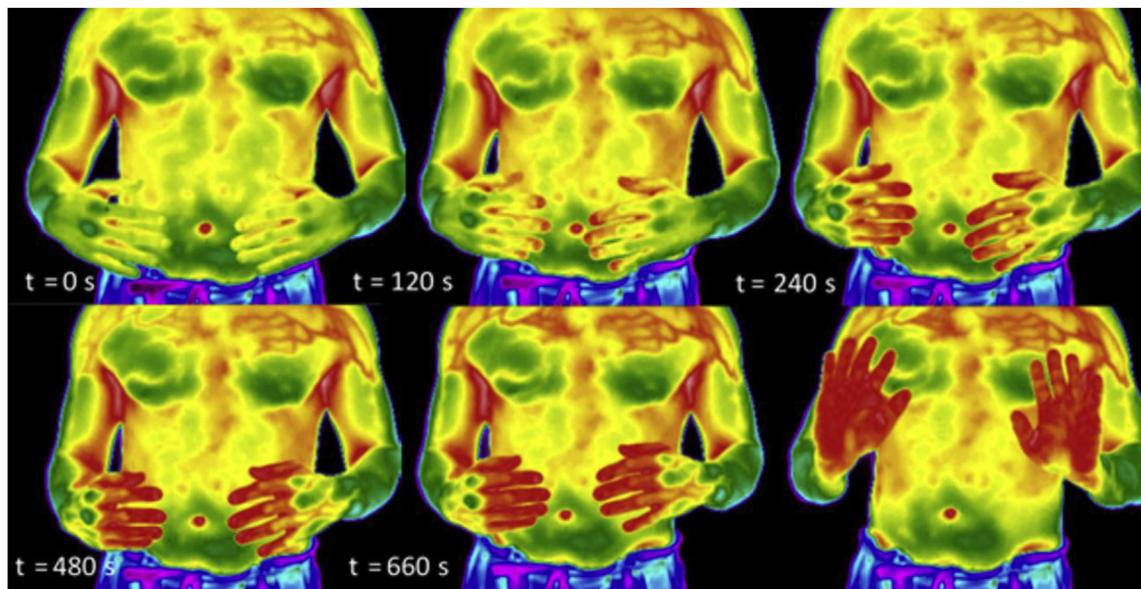


Fig. 1. Infrared thermography measurements during *Qigong* practice (adapted from (Matos et al., 2012)).

endogenous, due to the natural state of the body and the bio-physical effects of the practices under investigation.

Considering TCM's dialectical view of human anatomy and physiological regulation, and by focusing on the principle of the *yin/negative–yang/positive* polarity, we conducted this pilot study in order to assess the changes of the skin electrical potential in acupoints from the *Ren Mai* and *Du Mai* conduits, as well as in other points of interest, during *Qigong* practice.

## 2. Methods

### 2.1. Sample and study design

This pilot study was conducted at the Institute of Biomedical Sciences Abel Salazar and was approved by the Ethics Committee of the University of Porto. Two healthy Caucasian males, Subject A and Subject B, aged 37 and 33 years old respectively, with previous experience in *Qigong*, were selected for this study. In accordance with the Helsinki Statement, the participants signed a written consent and were informed that they could withdraw at any moment without consequences and that their anonymity was guaranteed. On different days, infrared thermography and electrical potential measurements were taken. Infrared thermography methodology was well described in a previous publication (Matos et al., 2012). The electrical potential measurements were taken using the acupoint *Yongquan*, KI 1 as a negative reference point. *Mingmen*, GV 4, *Shendao*, GV 11 and *Baihui*, GV 20, from the Governing Vessel; *Huiyin*, CV 1, *Qihai*, CV 6, *Zhongwan*, CV 12 and *Danzhong*, CV 17 from the Conception Vessel; *Yintang* (EX-HN3), *Laogong*, Pc 8; and the tip of the index and middle finger of both hands were measured. Points were located using the traditional relative measurement system and the *cun* proportional units (Focks, 2008).

Control experiments were conducted on the same day, with the same subjects, and under the same environmental and instrumentation measurement conditions. Therefore, two consecutive measurements were performed; firstly the control, and immediately afterwards, following the *Qigong* exercise, both with the same duration. In these two runs, the physical posture adopted was the same; however, the intention and mental focus (i.e., the endeavour to achieve a special mental state of awareness) were active only during *Qigong* (see Fig. 2).

In order to verify whether the changes in electrical potential were related or not to the selected acupuncture points, two additional experiments were performed. These experiments were conducted on Subject A, in exactly the same way as previously described, that is, with a control and with a *Qigong* run. Subject A was chosen because of the higher electrical potential differences measured during the initial tests. In the first experiment, the electrical potential was continuously measured on CV 6, and in the second, it was continuously measured at a non-acupuncture point nearby; in both experiments, the measurements were performed with reference to KI 1. The non-acupuncture point was horizontally aligned with CV 6, at a distance of 3 *cun* to the right side of the body.

### 2.2. Electrical potential measuring system

Experiments were performed with Ag/AgCl ECG paediatric electrodes (Ewemed) connected through wires to a National Instruments NI USB 6015 high-resolution data acquisition card. Paediatric electrodes were used because their small size facilitated their placement over the selected acupoints and other skin zones and minimised the amount of adhesive material around the measured points. Connections to the analogue input channels were made in single-ended mode, considering the acupoint KI 1 as the

negative pole, or ground, shared with all channels. The data acquisition interface was developed in Labview 8.2 from National Instruments. The program was built in order to acquire and save real-time data with a configurable acquisition frequency. The user interface allowed direct visualisation of the electrical potentials, and the acquisition subroutine on the block diagram was set to multichannel reading with one sample on demand, which enabled the system to operate at its maximum acquisition capacity. Fig. 2 shows the wiring diagram with the selected acupoints connected to the analogue input channels of the data acquisition card.

### 2.3. Qigong system and training

The *Qigong* exercise selected for this study was the White Ball standing exercise, performed according to the Heidelberg model of TCM. It is a non-dynamic, basic *Qigong* posture, similar to the *Wu Chi* posture in the *Zhan Zhuang* system, in which the participant imagines holding a rice-paper ball in front of the lower *Dantian*, thus excluding the effects of physical movement. The main aspects of this exercise have been well described in the literature (Greten, 2009; Johnson et al., 2000; Jin et al., 1996). Both subjects had at least three years of experience practicing this *Qigong* system.

### 2.4. Statistical analysis

Electrical potential values were submitted to *t*-tests for independent samples and to Pearson's correlation analysis in order to evaluate the statistical significance of the observed differences and to detect relationships between variables. The analysis was performed with Statistica for Windows version 7.0.

## 3. Results

Thermography indicated an increase in the subject's skin temperature while performing the *Qigong* exercise. This change resulted from the increase in local microcirculation in the hands of both subjects. During the experiments, the *qi* sensation was reported only when microcirculation increased. Electrical potential measurements on the tip of the middle finger (RMF – right middle finger; LMF – left middle finger), on the tip of the index finger (RIF – right index finger; LIF – left index finger) and on Pc 8 R, right hand, and Pc 8 L, left hand, with reference to KI 1, were significantly different ( $p < 0.01$ ) between the control and *Qigong* runs. In a comparison of the two subjects, the tendencies and magnitude of variation were also significantly different (see Fig. 3) but not correlated between each other ( $r = 0.1509$ ,  $p = 0.7750$ ).

As shown in Fig. 4, the electrical potential at the selected points from the *Ren Mai* and *Du Mai* conduits, as well as at the additional acupoint EX-HN3, also changed considerably between the control and *Qigong* runs. With the exception of CV 17 ( $p = 3282$ ), Subject A presented statistically significant increases in potential in all acupoints ( $p < 0.01$ ). Regarding Subject B, GV 4 and EX-HN3 did not exhibit significant changes ( $p = 0.5285$  and  $p = 0.8428$ , respectively). Conversely, the remaining points changed significantly ( $p < 0.01$ ).

The comparison between the electrical potential on acupoints from the *Ren Mai* and *Du Mai* conduits enabled the detection of the expression of a stronger electronegative potential in *Ren Mai* than in *Du Mai*, both in control and during *Qigong* for Subject A, and only during *Qigong* for Subject B. These changes were positively correlated between the two subjects ( $r = 0.7966$ ,  $p = 0.0180$ ).

Real-time electrical potential measurements on CV 6 and in a non-acupuncture point nearby, with reference to KI 1, were taken during control and *Qigong* runs. As Figs. 5 and 6 show, the

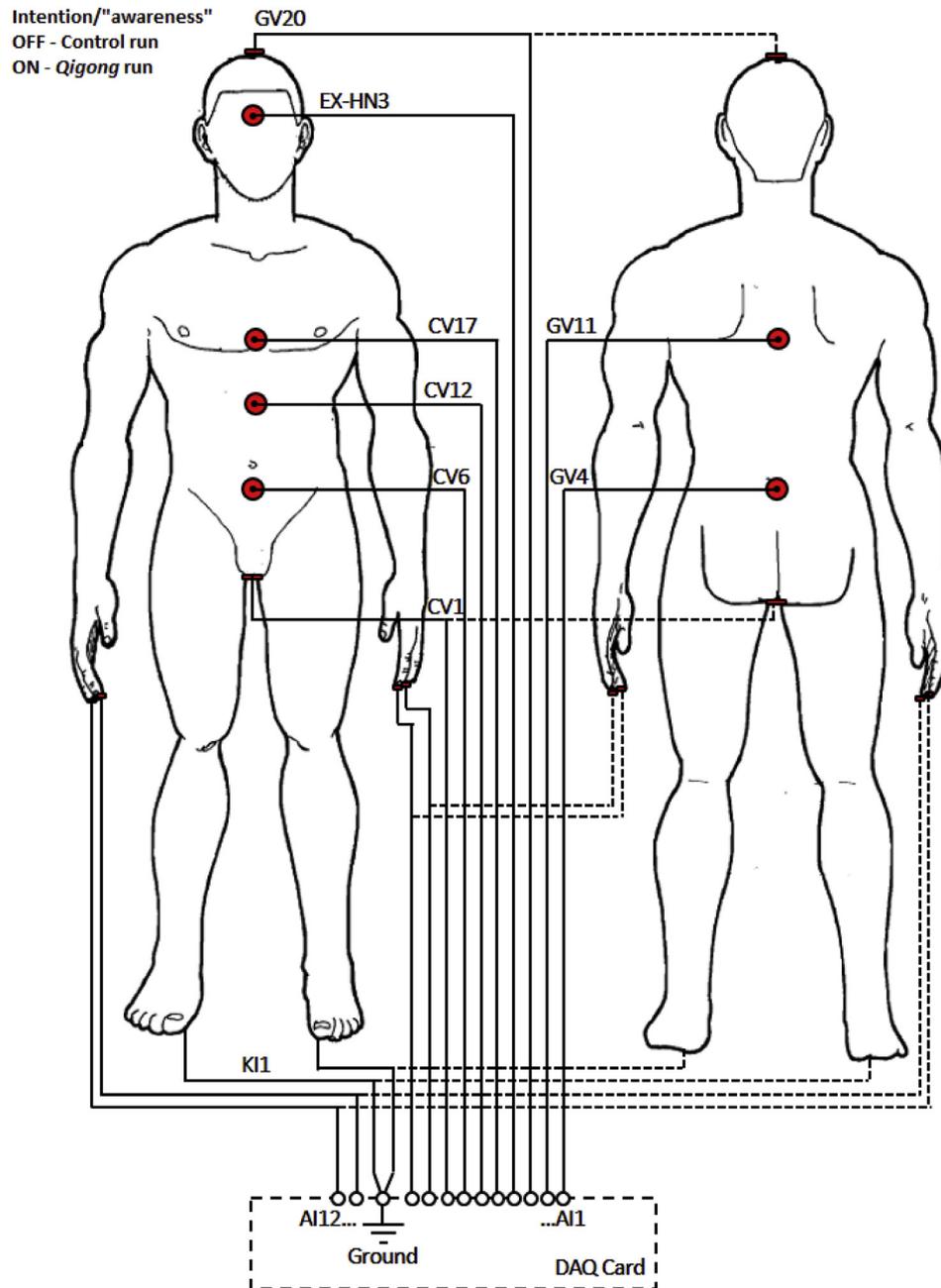


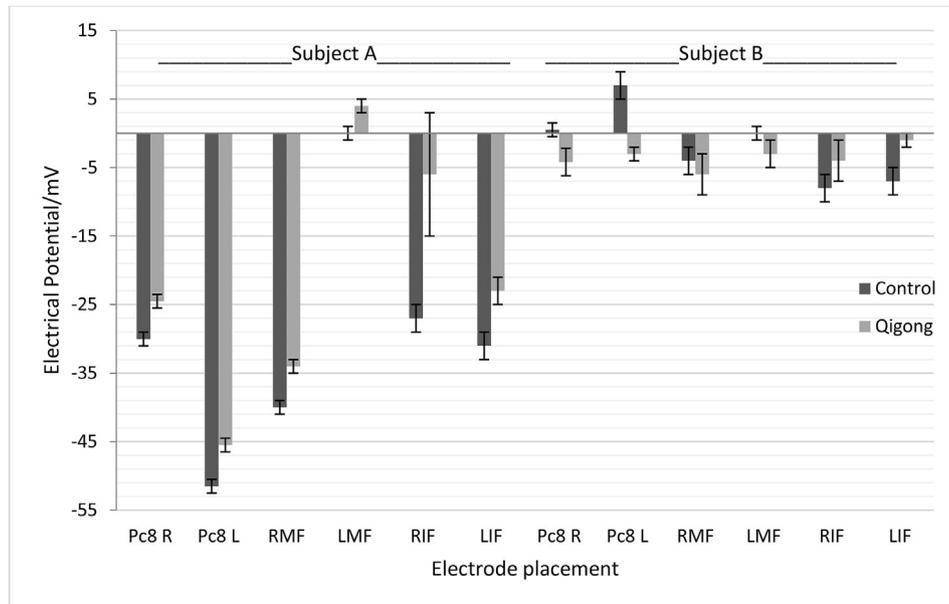
Fig. 2. Wiring diagram showing the selected acupoints connected to the analogue input channels of the data acquisition card (DAQ) and the two possible intention/awareness states (body illustration adapted from (Johnson et al., 2000)).

potential profiles had different tendencies. In the non-acupuncture point, during both the control and *Qigong* runs, the potential remained almost stable around a mean value (see Fig. 6), whereas in CV 6 the potential tended to increase significantly during *Qigong* (see Fig. 5).

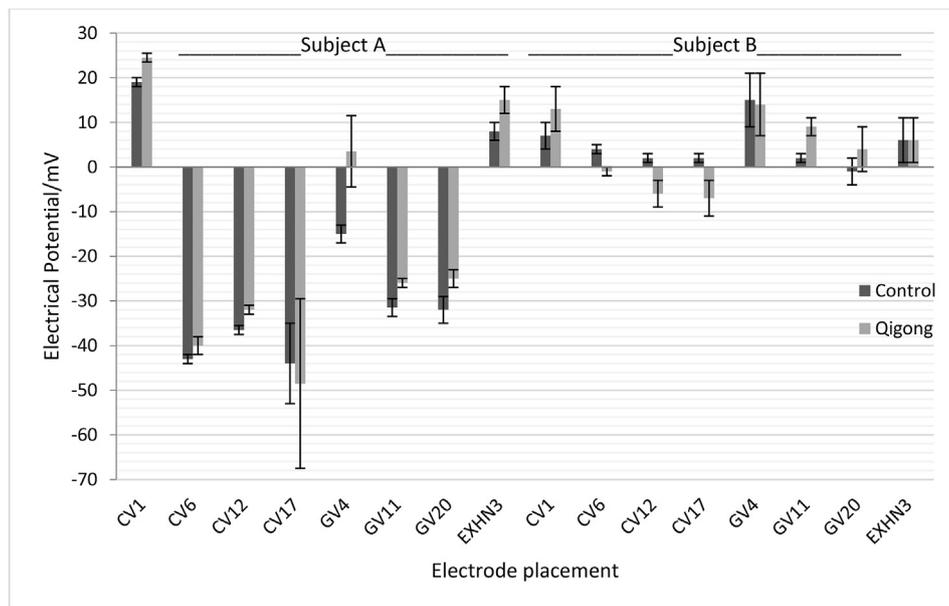
In fact, in the first set of two experiments, when the electrode was placed on CV 6, the measured differences between control and *Qigong* runs were highly significant ( $p < 0.001$ ), in contrast to the low level of significance found, for example in experiment 2, when the electrode was placed on the non-acupuncture point ( $p = 0.5961$ ). Regarding experiment 1 of the second set of experiments, a statistically significant level was achieved; however, this value lacked practical significance, because it was discarded by the graphical analysis.

#### 4. Discussion

TCM's dialectical view of human anatomy posits that the human body is an organic, interconnected, and functional whole based on the union of opposites, in which every tissue or organ can be assigned to either *yin* or *yang* (Liu and Liu, 2011). This principle is also applied to physiological regulation and pathology, in which it could be understood as a directional norm convention, able to describe circular functions within a cybernetic regulatory context, such as *yin* (descending/downregulation) and *yang* (rising/upregulation). Moreover, from a medical point of view, *yin* could be understood as 'less *qi*' and *yang* as 'more *qi*'. Particularly relevant to the interpretation of our results is TCM's relative-polarity view of the body, according to which the upper part and back of the body



**Fig. 3.** Average electrical potential in selected points of the subjects' hands during control and *Qigong* experiments. Legend: RMF – right middle finger, LMF – left middle finger, RIF – right index finger, LIF – left index finger, Pc8 R – pericardium 8 right, Pc8 L – pericardium 8 left.



**Fig. 4.** Average electrical potential at selected points from the Ren Mai and Du Mai conduits, and at EX-HN3, during control and *Qigong* experiments.

are *yang*—and therefore positively charged, or less electro-negative—and the lower part and front of the body are *yin*—and therefore negatively charged, or more electronegative. The same applies to *yin* and *yang* conduits and can, hypothetically, be related to the driving force of the so-called ‘flow of *qi*’. These considerations have been supported by the work of Robert O. Becker, who showed that the body surface has a differential electrical polarity, as well as the ability to generate a direct current electrical charge involved, for example, in healing processes (Becker et al., 1985).

Few published studies have investigated changes in the electrical properties of acupoints during *Qigong* practice. To the best of our knowledge, there are only two published studies of the changes in electrical conductance measured before and after the practice of

*Qigong* (Sancier 1994, 2003). Although both studies showed that the practice resulted in significant differences, neither presented a real-time measurement profile of the exercise.

Our results show that electrical potential changes occurred in the course of the exercises, a phenomenon documented for the first time during *Qigong* practice. The changes were generally compatible with certain ancient theoretical assumptions of TCM. The observed potential tendencies were not equal within the *Ren Mai* and *Du Mai* conduits. In fact, as shown in Fig. 4, there was a tendency toward more negative potential within the (downwards) *Ren Mai* conduit or Conception Vessel and toward less negative potential in the (upwards) *Du Mai* conduit or Government Vessel.

At a particular point of the *Ren Mai* conduit, CV 1, both subjects

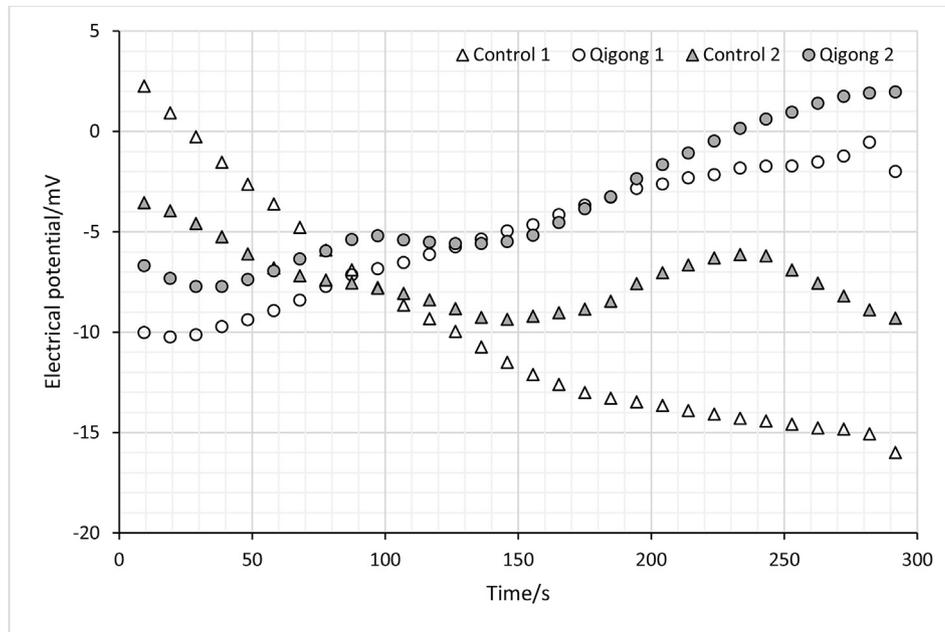


Fig. 5. Electrical potential measured at CV 6 with reference to KI 1 (Subject A) during control and *Qigong* experiments.

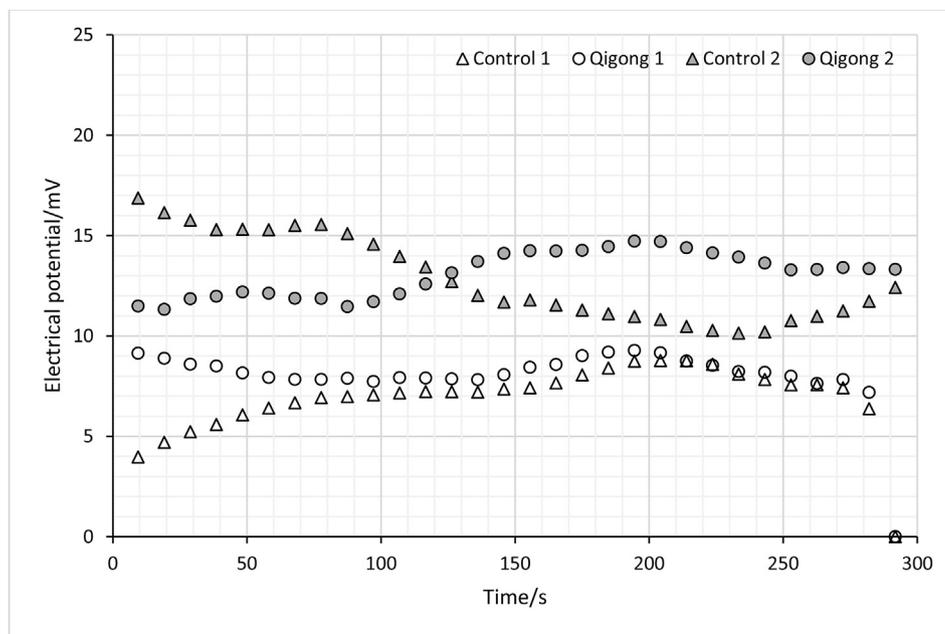


Fig. 6. Electrical potential measured at a non-acupuncture point near CV6 with reference to KI 1 (Subject A) during control and *Qigong* experiments.

exhibited a relatively high positive potential, which increased during *Qigong*. CV 1, located at the perineum, midway between the anus and the scrotum in men, is the meeting point between the *Ren Mai* and *Du Mai* conduits and is directly beneath and opposite to GV 20. This point is particularly important in *Qigong* practice and on the so-called small heavenly circuit rotation, or microcosmic circulation, in which the *qi* is focused and felt in the lower *Dantian*, directed to CV 1 and then to *Changqiang* (GV 1), before being directed up by the *Du Mai* to GV 20, and then down the *Ren Mai* to return to the lower *Dantian* (Deadman et al., 1998; Johnson et al., 2000). EX-HN3, another important point in *Qigong*, also exhibited a relatively high positive potential in both subjects. This acupoint,

located at the middle of the forehead, between the eyebrows, is the front point of the upper *Dantian*, traditionally known as the 'entrance of the spirit' and often associated with intuition, 'energy' projection, wisdom and enlightenment (Johnson et al., 2000). These theoretical particularities can hypothetically be related to the increased electrical potential measured in CV 1 and EX-HN3.

As noted above, several factors may influence the electrical potential on the selected acupoints. These include the stratum corneum impedance, the presence of sweat glands and skin moisture, blood flow perfusion, fluid balance and accumulation and dispersal of substances, to mention just a few. Moreover, changes in electrodermal measurements are often an indicator of sympathetic

nervous system activity during emotional manifestations (Mccorry, 2007; Kreibig, 2010). Indeed, sweat glands are innervated by postganglionic fibres of the sympathetic nervous system, because their functioning is highly influenced by emotional states (Mcgaugh, 2016). In this process, the central nervous activity related to affective and cognitive states triggers sweat secretion by the action of catecholamine neurotransmitters such as noradrenaline (Hu et al., 2017). Moreover, variations in sweating, activated by acetylcholine, are a function of environmental temperature and humidity (Sarchiapone et al., 2018; Kawai et al., 2008; Asahina et al., 2003). Nevertheless, at temperatures below the threshold of sweating, the electrical potential of the skin seems to provide a measure of the epidermal ion concentration gradient associated with physiological regulation (Kawai et al., 2008; Denda et al., 2001).

Considering that all the measurements were performed at stable room temperature; that all elements of distraction, such as other persons in the room, mobile phones and external disturbing noises, were avoided during the measurements; that the studied subjects were healthy, experienced *Qigong* practitioners who were accustomed to achieving a special state of awareness and able to control their own thoughts and balance emotions, our results also show that the changes in the electrical potential of acupoints may result from the *Qigong* exercise and may be triggered by intention and imagination, which, as reported by the subjects, was experienced as a special state of awareness. In this particular state of mind, the perception of *qi* resulted from the vegetative activation of physiological mechanisms. This is compatible with the Heidelberg model of TCM, which defines *qi* as a tissue or organ's vegetative capacity to function, which may be felt as tearing, pressure or flow when the tissue is activated. In the present study, this activation was an induction of microcirculation and changes in electrical potential. These results are in agreement with the principle that the mind activates the *qi* and that the latter moves the *xue*.

The electrical potential measured in the fingers and *Laogong* of both subjects was responsive to *Qigong*, but the tendencies were not correlated. Whereas Subject A exhibited an increased potential in all points, Subject B exhibited an opposite, decreasing tendency in *Laogong* and the middle fingers of both hands. Although thermography indicated an increase of blood perfusion in the hands of these individuals, which could explain the increased potential, other variables may have influenced the electrical properties of some points, thus requiring more research and leaving us, at this point, without a conclusive explanation.

As shown in Figs. 5 and 6, the electrical potentials measured in the acupuncture and non-acupuncture points had different tendencies during the practice of *Qigong*. Whereas in *Qihai* the changes in potential were noticeable and could be related to the exercises, in the non-acupuncture point, those changes seemed to be negligible. *Qihai* exhibited a higher load of electricity, and this shift in load may eventually be understood as some sort of current (bioelectricity). If the changes in bioelectricity and the related bioelectric flow can be explained in physiological terms, such an explanation could contribute to the understanding of the vegetative physiological changes associated with *qi* flow in TCM. Moreover, if the *qi* flow changes with the practice of *Qigong*, and these effects can be measured, then it is likely that '*qi* patterns' associated with an individual's constitution and disease can also be detected, quantified and related to TCM diagnoses.

#### 4.1. Study limitations

We are aware of the limitations of this study, particularly the small sample size and the lack of published material on this specific subject and the related assessments. A more extensive body of

research would help to mitigate errors and misunderstandings, which may eventually be detected in follow-up studies. It is also important to bear in mind that subjects experienced in the *Qigong* system investigated in this study are not easily found. Moreover, we do not know whether the changes have any relationship to the practitioner's level of experience, or whether they are triggered by a natural skill. These issues require further studies that include both experienced and inexperienced subjects. Also, to measure the differences in electrical potential, we chose KI 1 as the ground, or negative pole, shared with all acupoints. We did so because the renal conduit belongs to the *yin*, and because this point is in perfect contact with the biggest *yin* that exists, the Earth itself. However, we cannot ensure that the acupoint state is the same for all subjects, which may induce variability in the measurements, in terms of both polarity and signal magnitude. Further studies employing electrical potential measurements in acupoints should consider choosing other reference points.

## 5. Conclusions

The biophysical effects of *Qigong* as a vegetative biofeedback therapy, can be measured and quantified using various approaches, including measurements of the electrical potential of the skin. The changes in the electrical properties of acupuncture points and the possible association with the bioelectrical flow of charges during *Qigong* practice seem to be related to the practitioner's intention and are consistent with the theoretical foundations of TCM, that is, that the *xue* is moved by the *qi* and guided by the intention of the mind, the *yi*. Therefore, the activation of the *qi* flow depends on the practitioner's special mental state of awareness, which triggers the manifestation of vegetative physiological changes, such as the increase of the microcirculation and changes in the electrical potential of the skin. On the other hand, the main changes in electrical potential during *Qigong* practice occurred in acupuncture points. Such points, when linked together, form a meridian or conduit, in our case the *Ren Mai* and *Du Mai*, in which the relative polarity was in accordance with TCM's dialectical view of the human body.

## 6. Author contributions

L.C.M. conceptualized, designed and managed the study, collected and analysed data, and wrote the first version of the manuscript. J.P.M. participated in the experimental design, data analysis and revising the paper. H.J.G. and F.J.M. participated in the interpretation of data and revising the paper. All authors were active in the editing of this article and approved the final version.

## Conflicts of interest

The authors certify that there is no conflict of interest with any financial organisation regarding the material discussed in the manuscript.

Professor Henry Johannes Greten is the founder of the Heidelberg model of TCM. He teaches this model in the Master's degree of TCM at the Institute of Biomedical Sciences Abel Salazar of the University of Porto and uses it in his daily clinical practice.

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