Assessment of Short-term Acupuncture Effect Through Electro-conductivity Variation of Yuan-Source Acupoints

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ABSTRACT

Objective: To demonstrate that acupuncture has an instant effect in equilibrating the imbalanced electrical conductivity of Yuan-Source acupoints after intervention on the Luo-Connecting acupoint (one-side) of the same channel.
Methods: The experiment was designed as a randomized blinded control trial, with 56 volunteers. Reactive Electrical Permeable Points (REPP – mostly Yuan points) were measured in terms of electrical conductivity. Patients with a split-meridian (difference between left and right measurement) were randomly included in the control or experimental group. After five minutes of needle insertion in a Luo acupoint, the needle was removed and REPP were re-measured twice within a five minutes interval.
Results: From the 56 volunteers, 32 had a valid Split-Meridian Difference (SMD > 20 μA) and were included in the study. The results indicate that after the third measurement (15 minutes – M3), 100% of the experimental group had SMD < 20 μA and 55% was with a SMD = 0 μA. In contrast, for the control group, 92% remained with a SMD > 20 μA, at M3, when compared with the initial measurement (M1). Results obtained between the experimental and control group are significantly different ($p < 0.001$).
Conclusions: The present exploratory work indicates that there is evidence of instant body response to acupuncture that can be detected by changes in the electro-conductivity of specific acupoints.
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INTRODUCTION

Meridian and acupoint theory is a central subject in Traditional Chinese Medicine (TCM) upon which acupuncture intervention is fully based. In the attempt to show that the acupuncture mechanism of action goes beyond the nervous system, research has progressed to demonstrate the existence and nature of these channels. In 1963, in North Korea, Bong-Han Kim announced a structure that could be interpreted as the commonly known meridians, and called them Bong-Han ducts[1]. Decades later, successful scientific works demonstrated the existence of the channels[2] and several properties of these channels including electromagnetic and optical properties (biophoton)[3,4].

Other researchers found that several skin disorders would align in a path along the body that could be consistent with the trajectory of the meridians described in TCM[5]. Moreover, other researchers suggested that meridians could be related with the interstitial fluids that, in a specific channel would have a low hydraulic resistance, and that would be a vehicle of communication[6]. Intriguingly, it was found that an induced blockage of the low hydraulic channel corresponding to the TCM stomach meridian in a pig would induce gastrointestinal pathological changes (stomach and intestinal distention)[6].

Almost one decade before the work of Bong-Han Kim, Nakatani found that patients with nephritis would exhibit an exaggerated electrical conductivity in certain points on the leg when compared to adjacent areas[7]. Curiously, the alignment of those permeable points to electrical current would trace a path similar to the TCM kidney meridian. Dr. Nakatani called that path ryodoraku, that means "line of high electrical conductivity"[7].

Thus, past and recent studies indicate that the meridian network can conduct electricity, light and is sensible to physical pressure. Even more recently, a theoretical and exploratory work came forward with the hypothesis that meridians may have superconductor's properties[8].

An interesting information that the ryodoraku measurement can provide is the perception that a meridian can have different electrical conductivity on the left and right side, for the same acupoint. This condition is defined as a split-meridian. Despite the physiological meaning of a split-meridian is not fully understood, these responses are often found to correlate with states of disease and health[9,10]. The aim of the present work is to show that a split-meridian condition can be changed in a short-term period after an acupuncture procedure.

MATERIALS AND METHODS

Ethics Statement

The work described in this article was carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. Subjects provided written informed consent before participation in the study.

Participants

Fifty-six patients were recruited for the study: 20 were in the experimental group (16 females and 4 males), 12 were in the control group (6 females and 6 males) and 24 were excluded (see exclusion criteria). Volunteer students and workers from Institute of Biomedical Sciences Abel Salazar- University of Porto (Portugal) and Portuguese Institute of Naturology (Portugal) formed both experimental group and control group with ages between 19 and 59 years old. The statistics on age distribution for female and male participants is depicted in Figure 1.

Exclusion Criteria

Patients with a non-valid split-meridian (difference between measurements in the left and right limb for the same acupoint is under 20 μA) and/or under psychotropic medication were excluded.

Research procedure

Point measurement, split-meridian definition and acupuncture procedure

The measurement of REPP was performed with the IW-ZEN Ryodoraku neurometer. For each measurement, a 12 V direct current (DC) was used calibrated to a maximum of 200 μA. The stationary (grip) electrode is made of stainless steel and was held in the left hand of each patient while the measuring electrode is in contact with the acupoint for a maximum time of 5 seconds per point. The measuring electrode is equipped with a conical tip with cotton embedded in a saline solution (0.9% m/m of NaCl) and it is applied in contact with the skin at the acupoint location. Figure 2 is a representation of the IW-ZEN Ryodoraku apparatus.

The measured REPP are mainly Yuan-Source acupoints with the exception of Hégū (LI4) that was substituted by Yángxī (LI5). The twelve main channels were measured in terms of electrical conductivity (Table 1) and valid split-meridian was searched. A valid split-meridian was defined as when, for a specific channel, the REPP measurement of the left side was different relative to the right side by at least 20 μA. As an example, for the Lung channel, if the measured value for LU9 (Taíyuān) at the left side is 50 μA and the measured value for the same point at the right side is 70 μA a valid split meridian is present.

Thus, for each measurement one can have 3 possible scenarios (Figure 3): 1- there is no split-meridian (left and right side measurement are equal), 2 – there is a split-meridian but it is non-valid (the difference between the left and right measurement is under 20 μA), 3 – there is a valid split-meridian (the difference between the left and right measurement is equal or higher than 20 μA). For all the 12 pairs (left and right) of acupoints (24 measurements), patients can have more than one valid split-meridian. In that case, the split-meridian with the largest difference between sides was selected.

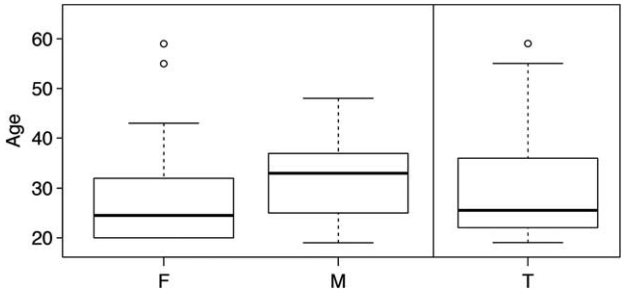

Figure 1. Trial participants age distribution – Age distribution of volunteer participants (F – female, M – Male, T – Total participants) in the present study. The minimum and maximum age all of the participants were 19 yrs to 59 yrs., being the 1st quartile: 22.5 yrs, median: 25.5 yrs and 3rd quartile: 36 yrs.

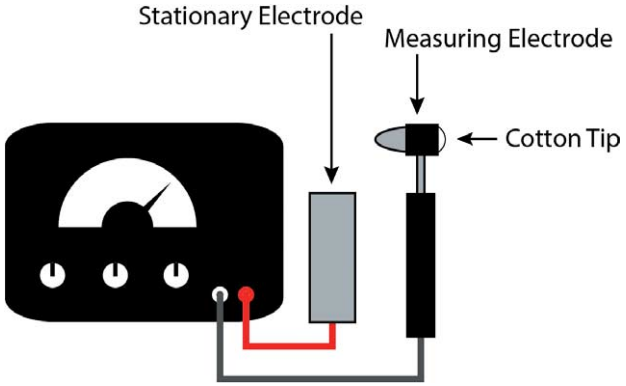

Figure 2. Schematic presentation of equipment – Ryodoraku measuring equipment representation. Stationary electrode is held in left hand of patients while the measuring electrode contacts the REPP with the cotton tip embedded in saline solution.

Table 1 – Measured REPP for all channels and corresponding punctured Luo acupoints (experimental group only) if valid split-meridian was detected.

Channels (meridians)	Measuring Points (REPP)		Luo Points	
	Ref.	Name	Ref.	Name
Lung	LU9	Taíyuān	LU7	Lièquē
Pericardium	PC7	Dàlíng	PC6	Nèiguān
Heart	HE7	Shénmén	HE5	Tōnglǐ
Small Intestine	SI4	Wàngǔ	SI7	Zhīzhèng
Sanjiao	SJ4	Yángchí	SJ5	Wàiguān
Large Intestine	LI5	Yángxi	LI6	Piānlì
Spleen	SP3	Tàibái	SP4	Gōngsūn
Liver	LV3	Tàichōng	LV5	Lǐgōu
Kidney	KI3	Tàixī	KI4	Dàzhōng
Bladder	BL64	Jīnggǔ	BL58	Fēiyáng
Gall Bladder	GB40	Qiūxū	GB37	Guāngmíng
Stomach	ST42	Chōngyáng	ST40	Fēnglóng

The experimental group was submitted to acupuncture in only one acupoint. The acupoint selected was always the Luo-Connecting point (Table 1) on the channel where the split was detected, and on the side where the lower value of electric conductivity occurs. Thus, for the example given previously (split-meridian detected in Lung channel), the electric current at LU9 - left side was 50 μA opposed to 70 μA at the right side. In this case, the Luo point of Lung channel (LU7 - Lièquē) was punctured at the left side (lower measured value).

Experimental phases

The experiment was divided in five consecutive phases (Figure 4). In phase 1, patient was at rest in supine position for 5 minutes. In phase 2, measurements of REPP were made

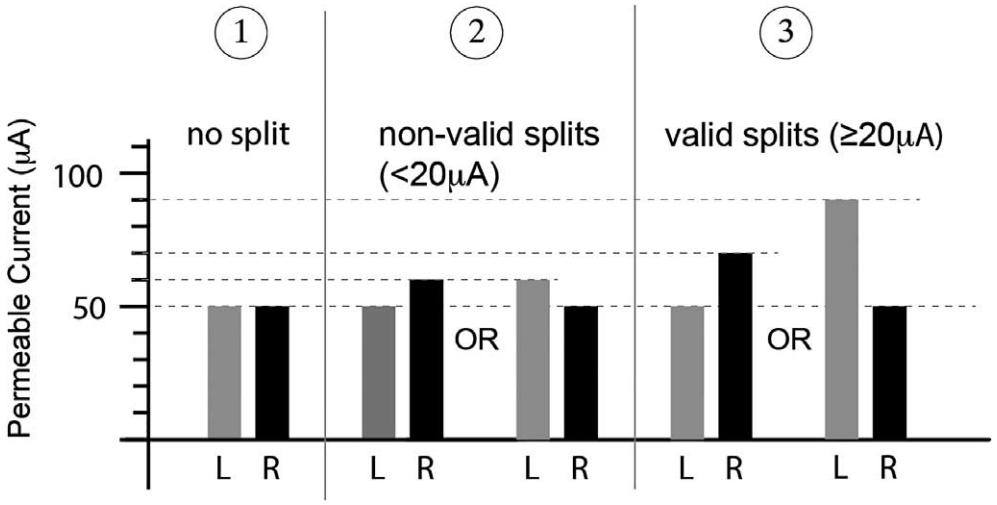

Figure 3. Possible scenarios during measurements – Graphical explanation of the three possible scenarios during the measurement of electrical conductivity in paired acupoints (the same acupoint in the left and right limb). Scenario 1 is when the measurement of the electrical conductivity in an acupoint in the left (L) limb is the same of the right (R) limb. Scenario 2 is when the electrical conductivity between left and right acupoints is different but under 20 μA, and is designated as non-valid split. Scenario 3 is when the electrical conductivity between left and right acupoints is different and equal or higher than 20μA, and is designated as a valid split.

for the 12 channels. If at least one valid split-meridian was found then the patient was allocated to the control group or experimental group. If no valid split-meridian was found the patient was excluded from the study.

In phase 3, the patients of the control group were at rest for 5 minutes. The patients of the experimental group were punctured in the Luo-Connecting point that belongs to the channel where the split-meridian was found, and at the limb side with the lowest electrical conductivity. The needle remained inserted for five minutes and then was removed. In phase 4, both patients in the control or experimental groups were measured in the same way as in phase 2, and they stayed an additional five minutes at rest. In phase 5, both patients in the control or experimental groups were measured in the same way as in phase 2. After this measurement the experiment was ended.

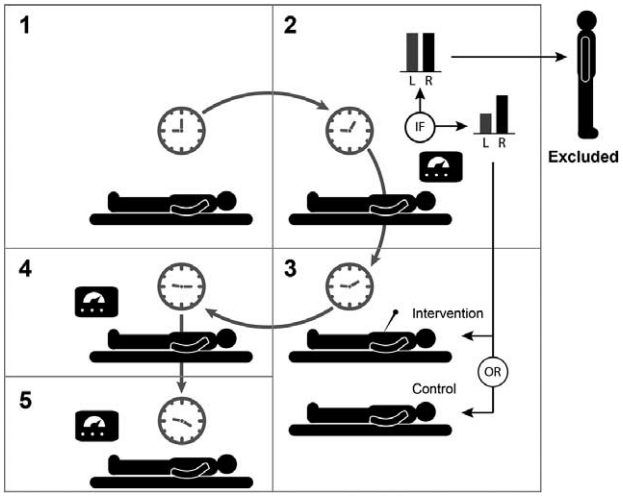

Figure 4. Trial phases exemplification – Depiction of the experimental phases. Phase 1: Rest phase – patients rest for 5 minutes in supine position; Phase 2: REPP measurement 1 – measurement of REPP and examination of split-meridians; Phase 3 – Intervention phase: control group stay at rest for 5 minutes while experimental group is punctured for 5 minutes; Phase 4: REPP measurement 2 – measurement of REPP in both control and experimental groups and additional 5 minutes resting period; Phase 5: REPP measurement 3 – measurement of REPP in both control and experimental groups and end of experiment.

Hypotheses and statistical tests

The present work aims to test the hypothesis (H1): "Patients with a split-meridian can level the values of electrical conductivity of the left and right side REPP in relative short-time period after acupuncture procedure on Luo-Connecting points", against the null hypothesis (H0) that is: "Patients with a split-meridian will experiment no reduction of the difference in electrical conductivity between the left and right side REPP, after acupuncture, in at least the same time period tested in H1".

The models and statistical tests used in the present work to assess the hypotheses were the linear fixed model and analysis of deviance. The dependent variable was SMD, the fixed factor was the groups and the covariate was the time. The interaction between time and group was significant due to similar values at time zero for both levels of group (experimental vs control). Individual was used as a random factor. An equivalent model without random factor was fitted and compared with the previous one by means of AIC (Akaike Information Criterion), resulting in the selection of the model with random factor (AIC = 755 (random factor model) vs AIC = 765) as the best model.

In order to accomplish the assumption of residual normality of the model, three outliers were removed based on the Bonferroni test for outliers. Normality was tested with Shapiro-Wilks test.

The mathematical software R (v.3.1.1) was used for all the models and statistical tests.

RESULTS

From the 56 volunteers, 32 had a valid split-meridian and were included in the study. For the experimental group, at the moment of the first measurement (M1 – Figure 5, right graph) 45% of the group had a split-meridian difference (SMD) of 20 μA, 30% of the group had a SMD = 25 μA, 15% of the group had a SMD = 30 μA and 10% had a SMD ≥ 35 μA. After the acupuncture intervention, the second measurement (M2) was performed and the results indicate that 90% of the group presented a SMD < 20 μA and 30% presented no SMD (SMD = 0 μA). The third measurement (M3 - five minutes after M2) revealed that 100% of the group had a SMD < 20 μA, 45% had SMD = 0 μA and 85% was with a split-meridian difference equal or less than 5 μA (Figure 5, right graph).

For the control group, at the moment of the first measurement (M1 – Figure 5, left graph) 33% of the group had a SMD of 20 μA, 17% of the group had a difference of 25 μA, 42% of the group had a difference of 30 μA and 8% had a difference of more than 35 μA. After the second measurement (M2) the results indicate that 75% of the group remained with a split-meridian with a difference equal or higher than 20 μA. After the third measurement (M3), 92% of the group had a split-meridian difference equal or higher than 20 μA. In all the experiment, no patient of the control group exhibited a total reduction of the SMD (SMD > 0 μA).

The analysis of the linear mixed model resulted in rejection of the H0 for the factor group (Table 2).

Table 2 – Results of the analysis of deviance performed with the linear mixed model fitted to SMD data. DF=Degrees of freedom.

Variable	DF	Chi-square	p-value
Group	1	57.2	<0.001
Time	1	41.5	<0.001
Residuals	26	-	-

DISCUSSION

The core interpretation of the results delivered through the present study is that Luo-Connecting acupoints have the ability to reduce the SMD value, or even eliminating the split-meridian (SMD = 0 μA), in a short-time period (≤10 minutes after needle removal). As shown in Figure 5, after 5 minutes of acupuncture intervention in the Luo-Connecting points, 30% of the experimental group had an SMD = 0 μA, which means that the split-meridian was fully eliminated. Additionally, after 10 minutes, 45% of the experimental group had no split-meridian, 85% had a SMD ≤ 5 μA and 100% with SMD ≤ 15 μA. Thus, the tested hypothesis H1 against H0 is significant (see Table 2) demonstrating that a SMD can be changed through acupuncture in corresponding Luo-Connecting point. The analysis of deviance also indicate that time is significant in the change of SMD for the experimental group (see Table 2).

Two important conclusions from this result are, (1) that a five minutes acupuncture intervention is enough to produce measurable changes in electrical conductivity of the skin in REPP points and (2) that the effect of reduction of the SMD is propagated in time (at least for 10 minutes – time defined in the present experimental work). The conclusion that acupuncture can have a fast physiological effect is corroborated by scientific work that shows the instant brain response to acupuncture[11]. As an example, researchers have found that acupuncture at GB34 (Yanglingquan) can have an instant effect in improving motor-cognition connectivity in hemiplegic stroke patients[12]. Thus, it is certain that responses through nervous system will happen to some extent,

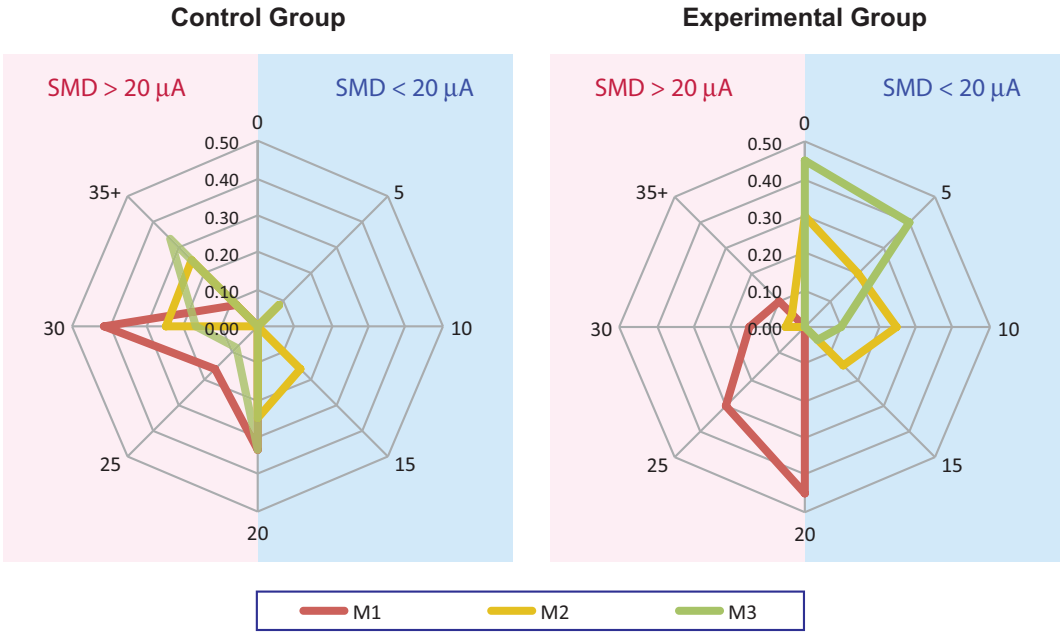

Figure 5. Control and Experimental group results –Representation of the normalized frequencies of the control and experimental groups, concerning the split-meridian differences (0 < SMD < 35+ μA) for the three measurement moments of the experiment (M1 – phase 2, M2 – phase 4 and M3 – phase 5).

sometimes also including brain regions like the cerebellum and limbic-related regions[13]. However, several studies indicated that the brain response that exists during the acupuncture stimulation may change over time[14–16]. In fact, with the present work we also concluded that the acupuncture effect is propagated in time, as changes in electrical-conductivity continue to happen after needle removal. A possible explanation for this result is that biochemical changes in the composition of the fluid in the channel (whether a Bong-Han duct[1] or low hydraulic resistance channel[6]) may happen. Changes in the composition and/or crystalline structure organization of proteoglycans associated with water molecules, specifically glucosaminoglycans (e.g. hyaluronic acid) would influence the electrical conductivity of the channel as proposed in previous work[8]. Another explanation may be associated with collagen fibers. It has been proposed that the acupuncture system may be related to the collagen liquid crystalline continuum in the connective tissues that can perform a fast semi-conduction of protons through a layer of structured water molecules[17]. However, these results must be interpreted carefully until *in vivo* analysis of the composition of these channels is preformed paired with electrical conductivity measurements.

From the present work several questions arise such as: does the nervous system send information for the local channel cells to change the biochemical composition of the interstitial fluid? Or does it happen by information propagated through the channel itself? Or is this a mixed response? Additionally, what are the implications of a re-established electrical conductivity to pathological conditions? Are these short-term changes ubiquitous in acupuncture points or is this a phenomenon particular to the Yuan-Luo relation? What other variables may affect both the extent and the speed of the observed corrections? Further work will be oriented to give insight on these questions.

CONCLUSION

From the present work we can conclude that the Luo-Conneting points have the ability to reduce or even eliminate the SMD of their corresponding channel in a short-time period (5 to 10 minutes). Additionally, after needle removal, the effect of SMD reduction is propagated in time. However, further work is needed to understand the physiological mechanisms of action of these points and implications in human health.

REFERENCES

1. Soh, K. S., Kang, K. a. & Ryu, Y. H. 50 years of Bong-Han theory and 10 years of primo vascular system. Evidence-based Complement. *Altern Med* 2013, 2013:587827.
2. Shin H.S., Johng H.M., Lee B.C., Cho S.I., Soh K.S., Baik K.Y., Yoo J. S., Soh K.S. Feulgen reaction study of novel threadlike structures (Bonghan ducts) on the surfaces of mammalian organs. Anat. Rec. *Part B New Anat* 2005,284(1):35–40
3. Session B., Bach E. Bonghan duct and acupuncture meridian as optical channel of biophoton. *J Korean Phys Soc* 2004,45:1196–1198.
4. Wijk R.V., Soh K., Wijk E.V. Anatomic characterization of acupuncture system and ultra-weak photon emission. *Asian J Phys* 2007,1–48.
5. Wang G.J., Ayati M.H., Zhang W.B. Meridian Studies in China: A Systematic Review. JAMS J. Acupunct. *Meridian Stud* 2010, 3(1):1–9.
6. Zhang W., Wang G., Fuxe K. Classic and Modern Meridian Studies : A Review of Low Hydraulic Resistance Channels along Meridians and Their Relevance for Therapeutic Effects in Traditional Chinese Medicine. Evidence-based Complement. *Altern Med* 2015,2015:410979.
7. Oda H. Ryodoraku Textbook: Ryodoraku Autonomic Nervous System Therapy. *Naniwasha Publishing Inc* 1993.
8. Fromknecht R., Goncalves M., Greten H.J., Machado J. Are conduits superconductor-like and supported by tetrahedra structure of hyaluronic matrix in living systems? New perspectives. *J Complement Integr Med* 2013,10:1–5.
9. Becker R.O., Reichmanis M., Marino A.A., Spadaro J. Electrophysiological correlates of acupuncture points and meridians. *Psychoenergetic Syst* 1976,1:95–212.
10. Kobayashi T. Early diagnosis of microcancer by cancer check of related acupuncture meridian. *Am. J. Acupunct* 1985,13.
11. He T., Zhu W., Du S.Q., Yang J.W., Li F., Yang B.F., Shi G.X., Liu C.Z. Neural mechanisms of acupuncture as revealed by fMRI studies. Auton. Neurosci. *Basic Clin* 2015,190:1–9.
12. Chen X., Zhang H.Z,Y. A functional magnetic resonance imaging study on the effect of acupuncture at GB34 (Yanglingquan) on motor-related network in hemiplegic patients. *Brain Res* 2015,1601:64–72.
13. Chae Y., Lee H., Kim H., Sohn H., Park J.H., Park H.J. The neural substrates of verum acupuncture compared to non-penetrating placebo needle: An fMRI study. *Neurosci. Lett* 2009,450(2):80–84.
14. Napadow V., Dhond R., Park K., Kim J., Makris N., Kwong K.K., Harris R. E., Purdon P. L., Kettner N., Hui K.K.S. Time-variant fMRI activity in the brainstem and higher structures in response to acupuncture. *Neuroimage* 2009,47(1):289–301.
15. Li C., Yang J., Park K., Wu H., Hu S., Zhang W., Bu J., Xu C., Qiu B., Zhang X. Prolonged repeated acupuncture stimulation induces habituation effects in pain-related brain areas: An fMRI study. *PLoS One* 2014,9(5):e97502.
16. Liu J., Qin W., Guo Q., Sun J., Yuan K., Liu P., Zhang Y., Deneend K. M., Liud Y., Tiana J. Distinct brain networks for time-varied characteristics of acupuncture. *Neurosci. Lett* 2010, 468(3):353–358.
17. Ho M.W., Knight D.P. The acupuncture system and the liquid crystalline collagen fibers of the connective tissues. *Am. J. Chin. Med* 1998,26(3-4):251–263.