



## RESEARCH ARTICLE

# Investigation of the Phenomenon of Propagated Sensation along the Channels in the Upper Limb Following Administration of Acupuncture and Mock Laser



Shohreh Razavy<sup>1</sup>, Marcus Gadau<sup>2</sup>, Shi Ping Zhang<sup>2,\*\*</sup>,  
Fu Chun Wang<sup>3</sup>, Sergio Bangrazi<sup>4</sup>, Christine Berle<sup>1</sup>,  
Mahrita Harahap<sup>1</sup>, Tie Li<sup>3</sup>, Wei Hong Li<sup>1</sup>, Christopher Zaslowski<sup>1,\*</sup>

<sup>1</sup> School of Life Sciences, University of Technology Sydney, Sydney, 2007, New South Wales, Australia

<sup>2</sup> School of Chinese Medicine, Hong Kong Baptist University, Hong Kong, SAR, China

<sup>3</sup> School of Acupuncture and Tuina, Changchun University of Traditional Chinese Medicine, Changchun, 130117, Jilin, China

<sup>4</sup> Istituto Paracelso, Rome 00153, Italy

Available online 11 July 2017

Received: May 23, 2017

Revised: Jun 22, 2017

Accepted: Jun 26, 2017

## KEYWORDS

acupuncture;  
De Qi;  
interoception;  
needling sensation;  
propagated sensation

## Abstract

**Background:** Similar to De Qi psychophysical responses, propagated sensation along the channels (PSC) is considered an important phenomenon in traditional Chinese acupuncture. In acupuncture clinical trials, different acupuncture manipulation techniques are used to enhance the propagation of sensation along the channels to facilitate an optimum therapeutic result.

**Aim:** To examine and compare the PSC reported by participants in a clinical trial following the administration of acupuncture and inactive mock laser.

**Methods:** The study was embedded in a two-arm parallel design multicenter, randomized clinical trial, the Tennis Elbow Acupuncture—International Study—China, Hong Kong, Australia, Italy (TEA IS CHAI). Needle sensations were measured using a validated instrument, the Massachusetts General Hospital Acupuncture Sensation Spreading Scale. Ninety-six participants with lateral elbow pain were randomly allocated into two groups in a 1:1 ratio; the acupuncture treatment group ( $n = 47$ ) and the mock laser control group ( $n = 49$ ). Participants in both groups received

\* Corresponding author. School of Life Sciences, University of Technology Sydney, PO Box 123, Broadway, Sydney 2007, New South Wales, Australia.

\*\* Corresponding author.

E-mail: [chris.zaslowski@uts.edu.au](mailto:chris.zaslowski@uts.edu.au) (C. Zaslowski).

the intervention at two acupoints, LI10 and LI11, consisting of 2 minutes of either standardized needle manipulation or mock laser at each acupoint with a rest period between each intervention period. Data were collected immediately following the interventions at the first and the ninth session within the clinical trial.

**Results:** Although participants in both groups perceived PSC radiating to similar sites along the upper limb, the frequency of the reported radiation sites among the two intervention groups for both radiation up the limb ( $p < 0.05$ ) and radiation down the limb ( $p < 0.001$ ) were statistically significantly different. Among the radiating sensation sites recorded within the two study groups, the sensations were reported as radiating a greater distance down the forearm to the wrist compared to up the arm. Evaluation of PSC across the four study sites revealed a statistically significant difference in frequency of the reported radiation down the limb sites in each study group and radiation up the limb sites only in control group only ( $p < 0.001$ ).

**Conclusion:** The findings of the study demonstrated that the PSC phenomenon is not just associated with needling but can be perceived when using a mock laser.

**Trial registration:** Australian and New Zealand Clinical Trial Registry reference: ACTRN12613001138774 on 11th of October 2013.

## 1. Introduction

Propagated sensation along the meridians [1–4], or the more frequently used term, propagated sensation along the channels (PSC) [5–8], appears to be a commonly observed *Jingluo* (channels and collaterals) [经络] phenomenon in acupuncture [9,10]. The phenomenon occurs most frequently following stimulation to an acupoint using acupuncture [1,10–13], electrical impulses [1,10,11,14], acupressure with qigong [11], meditation [15], and moxibustion [12,13]. Although the phenomenon was first documented in the early Chinese medical text, the *Neijing* [内经]—“when hitting a point, a needle seems to move along the street (channels)” [3], the first scientific account of PSC was reported in the 1950s [16–18]. Indeed, after 1949, Chinese manuscripts have emphasized the patient’s migratory needling sensory responses [19]. Other channel-related phenomena such as skin discoloration were also extensively studied in 1972–1987 [9]. In many texts, although PSC purports to be genuine evidence for the functional existence of channels [6,11,13,15,20,21], there is a lack of objective and systematic experimental studies [21] to support morphological evidence [7,9].

The term is often described as a radiating or spreading sensation away from the stimulated acupoint along the pathway of the defined channel [6,14]. Similar to De Qi [得气] (frequently known as obtaining Qi) [22–25], PSC is purported to be a key element in achieving a satisfactory therapeutic effect in acupuncture [2,11,14,17,26–28] particularly when the sensation radiates toward the pathological site [1,10,11,29,30]. This belief is expressed in the chapter of the *Ling Shu* titled “Nine Needles and Twelve Source Points,” which states that “Puncturing at the primary acupoint, the chi transmitting toward the pathological focus has the best treatment result” [11]. The *Ling Shu* further describes PSC as “Chi traveling toward a pathological focus can affect disease” [18].

The characteristic of the transmitted sensations may be reported as tic-like, burning, dullness, or pressure [17]. Other related sensations are described as soreness

[2,10,17,31], numbness [2,10,17,31], distension [2,10,31], heaviness [2,10,31] cold, heat, itching, and sensations of water/gas running, or like worms crawling [17]. Sometimes, visual signs such as redness, gooseflesh, or localized red/white lines along the channels are also postulated to be the manifestation of PSC [32].

Like De Qi, PSC has a long tradition in acupuncture research [6,10]; however, the phenomenon has only been partially elucidated [6]. Although PSC is often referred to as another feature of De Qi [6,27,32,33] or the extension of De Qi [14], it is frequently described as spreading–radiating [23,34–37], and the phenomenon appears to also reflect the technical term of *Qi Zhi* [氣至], “arrival of Qi” at the diseased area [10,15,22,26,38]. In the acupuncture literature, the terms De Qi and Qi Zhi are commonly perceived as referring to the same connotation [6,19,26,39–41]—“Deqi normally called Qi zhi in ancient, or needling sensation in modern” [26]—and few attempts have been made to segregate the characteristics between the two phenomenon [22,42,43]. Some authors have stated that the sensation of the arrival of Qi not only contains De Qi but also includes the PSC phenomenon [2].

Although a number of acupuncture sensation measurement scales have been developed to quantify De Qi psychophysical responses [34,36,37,44,45], investigation of PSC has been limited by a lack of appropriate methods for its assessment [6]. One such scale to measure PSC is the Massachusetts General Hospital Acupuncture Sensation Spreading Scale (MASS-S); however, the scale allows only an approximate estimate of the spreading/radiation experienced and reported by participants [6]. Another research group has also developed a questionnaire to capture the migratory sensation especially in comparison to static needling sensations [46]. The scale, however, was later criticized, stating that the patients’ experiences were not well reflected [47]. Given that PSC may serve as an essential part of acupuncture efficacy, the main objective of this study was to investigate the PSC specific sites of migration sensations in participants and compare the two different study groups and across the four regional trial sites/cultures.

## 2. Methods/design

### 2.1. Trial design and randomization

Key items of the study were prepared according to STRICTA (standards for reporting interventions in clinical trials of acupuncture) and CONSORT (Consolidated Standards of Reporting Trials) statements [48,49]. This study was embedded in a randomized, single blinded and controlled (outcome assessor and participant) clinical trial, the Tennis Elbow Acupuncture—International Study—China, Hong Kong, Australia, Italy (TEA IS CHAI), to investigate the efficacy of acupuncture for the condition of lateral elbow pain. Participants were randomly assigned to one of the two groups, Traditional Chinese acupuncture (treatment group) and inactive mock laser therapy (control group), in a 1:1 ratio. The trial was registered with the Australian and New Zealand Clinical Trial Registry following approval from each of the four institution's ethical committees and adhered to the provisions of the Declaration of Helsinki [50]. For full details regarding participants, the rationale behind chosen interventions, and needling and mock laser procedures, please refer to the published protocol [51].

### 2.2. Participants

The study was conducted from June 2013 until November 2014 at the outpatient clinics attached to each institution at four study sites. A total of 235 suitable participants were invited for screening. After clinical examination for inclusion and exclusion criteria (Table 1), 96 participants with chronic lateral elbow pain ( $n = 24$  per study site) met the eligibility criteria and were randomly assigned to acupuncture group (46.8% males and 53.2% females) and control group (57.1% males and 42.9% females). The median age ( $\pm$ standard deviation) of patients in acupuncture and control group were 49 ( $\pm 9.8$ ) and 50 ( $\pm 12.1$ ), respectively, with no significant difference between the two groups ( $p = 0.52$ ) (Table 2). All participants gave informed consent, and ethics approval was obtained at all four sites.

### 2.3. Size of the sample

The estimated sample size for the current study was obtained from the result of a pilot study undertaken by one of the research groups [52]. As a conservative measure the highest standard deviation was used, and at a 5% significance level, a sample size of 70 participants would lead to a

power of 99% [53]. Accordingly, a sample of 96 participants (24 at each trial site) was decided for the current study with the purpose of allowing approximately 25% dropout rate from different study sites.

### 2.4. Outcome measure

The supplementary MASS-S [19] was used to measure "radiating/spreading" sensory responses elicited by the two interventions (acupuncture and inactive mock laser). The scale was further amended to account for the measurement of sensations radiating both proximally up the upper limb as well as distally down the forearm from the used acupoints, Large Intestine 11 (LI11-Quchi) and Large Intestine 10 (LI10-Shousanli). Different words were used to specify different radiating sites on the affected limb, the former used "none," "local," "lower arm," "upper arm," "shoulder," and "neck," whereas the latter used "none," "local," "upper forearm," "lower forearm," "wrist," and "beyond," respectively, using the rating scale (see Fig. 1).

Participants were informed of the MASS radiating instructions after each intervention and prior to administering the scale. Participants were then asked to mark the site that best corresponded to their radiated sensation (PSC) experienced during each designated intervention following two measurement sessions (baseline and Session 9) immediately after administration of each intervention, either the acupuncture or the mock laser.

Additionally, a Credibility Rating Scale was administered to all participants to evaluate the credibility and adequacy of the mock laser control [54]. For further details, please refer to the published protocol [51].

### 2.5. Statistical analysis

The data were analyzed using the statistical program, Statistical Package for the Social Sciences (SPSS, IBM, USA) (version 22). Fisher's exact test was performed to investigate the rate of radiating incidence at different sites between the two study groups on the data pooled from the time factor (measurement sessions).

The same statistical method was also used to investigate the ratio of the individual reported sites for radiation down the limb (RDL) and radiation up the limb (RUL) for each study group. Additionally, the rate of radiation's occurrence in each study group among different trial sites was examined. The significance level was set at  $\alpha < 0.05$ , two-sided.

**Table 1** Inclusion and exclusion criteria used to recruit participants for the clinical trial.

Inclusion criteria	Exclusion criteria
Age, 18–80 years	Central or peripheral nervous system disease
Men and women	Inflammatory rheumatic diseases
Chronic lateral elbow pain (Duration $\geq 3$ months)	Gout
Unilateral localization	Earlier episodes of lateral elbow pain treated surgically or with
	- Acupuncture treatment or physiotherapy for tennis elbow within the previous 3 months
	- Acupuncture treatment for any problems within the previous week
	- Concurrent physiotherapy for tennis elbow

**Table 2** Baseline demographics of participants.

Items	Acupuncture	Mock laser	Median difference
Male (%)	22 (46.8)	28 (57.1)	n/a
Female (%)	25 (53.2)	21 (42.9)	n/a
Age median ( $\pm$ SD)	49 ( $\pm$ 9.8)	50 ( $\pm$ 12.1)	$p = 0.52$
Duration of LEP (in months) median (interval)	6 (3–96)	6 (3–200)	$p = 0.92$

LEP = lateral elbow pain; n/a = not available; SD = standard deviation.

### 2.6. Ethics approval and consent to participate

Human ethics approval was sought and obtained at each site (University of Technology Sydney, Australia; Hong Kong Baptist University, Hong Kong; Changchun University of Traditional Chinese Medicine, China; Istituto Paracelso, Italy). This trial was registered with the Australian and New Zealand Clinical Trial Registry on October 11, 2013 (Identifier: ACTRN12613001138774).

### 3. Results

The spreading sensation was measured using the MASS Radiating scale that is considered a categorical/nominal scale, where the expected counts of the  $R \times C$  table (where  $R$  is the number of rows and  $C$  is the number of columns) are small [55], and therefore Fisher’s exact test was used.

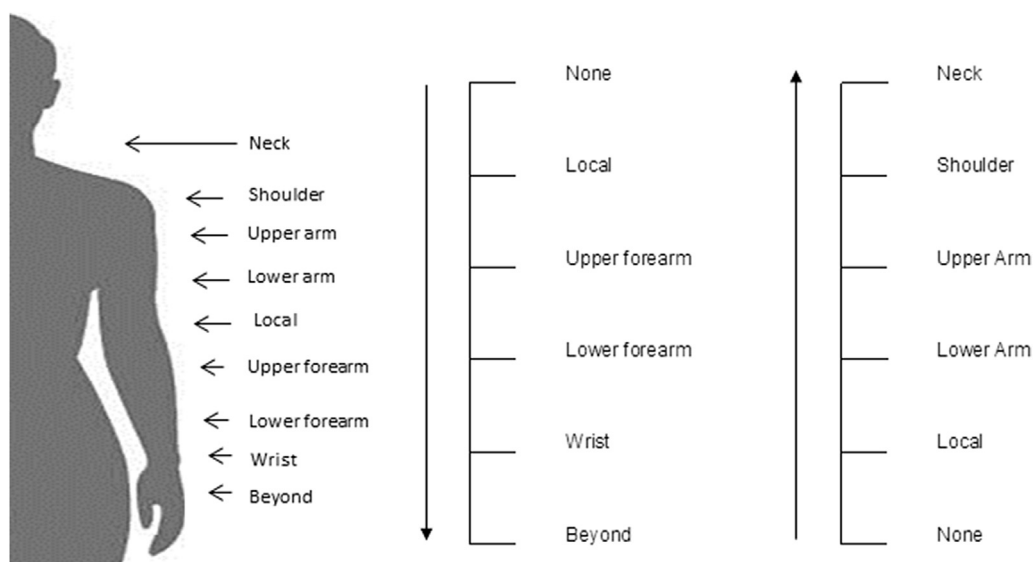
Of 96 eligible participants, 12 were excluded. This is because one trial site did not administer the MASS to the mock laser participants ( $n = 12$ ), resulting in unequal numbers in each group (acupuncture 47 compared with mock laser 37). Accordingly, the MASS questionnaire was administered to 84 participants, the acupuncture group ( $n = 47$ ) and the mock laser group ( $n = 37$ ), at two measurement sessions (baseline and Session 9). Both time

factor and sex for both RUL and RDL in each intervention group were investigated, and as there were no statistically significant differences between these scores, the data for measurement sessions 1 and 9 were merged together.

The result of the Credibility Rating Scale administered prior to Session 1 indicated no significant difference between the two groups for both expectancy of complaint’s improvement ( $p = 0.772$ ) as well as the rationale for treatment ( $p = 0.768$ ). This implies that the control mock laser intervention compared to the needle acupuncture was perceived as being credible, as well as adequate, in this study setting.

Following the administration of the acupuncture and mock laser, participants reported spreading sensations along the affected limb in different directions, namely, RDL and RUL. Interestingly, participants in the control group reported similar radiating patterns to the acupuncture group. However, when comparing the radiation of sensations both up and down the upper limb, a statistically significantly difference in frequency of the reported sensation between the acupuncture group and the mock laser group for RDL ( $p < 0.001$ ) and RUL ( $p < 0.05$ ) was observed.

The ratio of radiation/spreading sensory responses’ occurrence was also compared between the two study groups. Descriptively, the presence of the radiating sensation was considered when the reported sensation spread



**Figure 1** Modified MASS acupuncture sensation spreading scale (MASS radiating scale) that measures the spreading/radiating sensory responses up and down the limb from the used acupoints, LI11-Quchi and LI10-Shousanli, during administration of acupuncture and mock laser. MASS = Massachusetts General Hospital Acupuncture Sensation.

some considerable distance either up or down the limb from the treatment (Local) site. When “None” and “Local” sites were excluded, the incidence rate for RDL in acupuncture group was 50.6% compared with 29.2% in control group. By contrast, the ratio for RUL was slightly decreased in the acupuncture group (34.6%) compared to the mock laser group (27.4%).

Examination of the individual reported sites for RDL within each study group revealed the following ratio: “none” (2.2%, 37.5%); “local” (47.2%, 33.3%); “upper forearm” (13.5%, 4.2%); “lower forearm” (16.9%, 9.7%); “wrist” (6.7%, 5.6%); and “beyond” (13.5%, 9.7%) for acupuncture and mock laser, respectively. The RUL sensations reported by the two groups were: “none” (16.7%, 40.3%); “local” (48.8%, 32.3%); “lower arm” (13.1%, 14.5%); “upper arm” (16.7%, 6.5%); “shoulder” (3.6%, 4.8%); “neck” (1.2%, 1.6%) for the acupuncture and mock laser, respectively. Additionally, among the radiating sensation sites recorded within the two intervention groups, the sensation was reported as radiating a greater distance distally down the forearm (from the elbow) to the wrist compared to proximally up the arm (from the elbow) considering each intervention group (Table 3; Figs. 2A and 2B).

Frequencies of the reported radiation sites for both RDL and RUL in each study group among different trial sites were also investigated. The result revealed a statistically significant difference in frequency of the reported RDL among various radiation sites ( $p < 0.001$ ) across the four study centers for the acupuncture group; however, frequency of RUL different sites remained similar ( $p = 0.064$ ). In the control group, the reported frequencies of both RDL and RUL sites were statistically significantly different across the three trial sites ( $p < 0.001$ ).

Following administration of the acupuncture, participants in each trial site—Hong Kong (HK), Australia (AUS), China (CHA), and Italy (ITY)—reported differently on how often the various radiation sites were selected. Comparison of the individual reported RDL sites revealed that the foremost selected site was “Local” shared between CHA (73.9%) and ITY (75%). Additionally, participants in HK and AUS reported “Beyond” (36.4%) and “Lower Forearm” (29.2%), respectively, as their most frequent RDL sites. In contrast, “Local” was selected as the foremost reported site between other RUL sites by all the study sites.

In the mock laser group, “None” was selected as the leading RDL and RUL site reported by participants in HK (56.5) and AUS (60.9). By contrast, “Local” (75.0%) was the most frequent RDL and RUL site reported by participants in “ITY” (Table 4).

#### 4. Discussion

The current study provides quantitative data on the perceived radiation of sensation following manual acupuncture and mock laser, specifically the frequency of reported radiation to RDL and RUL sites in each study group, and the comparison of RDL and RUL across four different trial sites.

PSC [56] and latent PSC [57] are considered to be common phenomena that have been observed in a large number of individuals. The results from our study demonstrate that

PSC is not just a specific characteristic of acupuncture, as participants in the control group who received mock laser also reported radiation sensations transmitted along the various sites of the treated limb. Although both upward and downward radiation sensations occurred, they were reported to have been at a significantly lower frequency for the mock laser group. Although in our study sketching of perceived spreading sensations along the channel was not examined, results from one study suggested PSC in close connection with classical meridian pathways was observed when laser acupuncture was applied [6].

The current study provided experimental evidence suggesting that PSC, similar to the De Qi psychophysical response, can be elicited without physical needle insertion [58]. This may be that PSC as subjective sensations [2,9,21] are not essentially reliant on the activity of peripheral nervous system structures [13,14,21,59], and support from research on phantom limb phenomena [13,14,56] may signify involvement of the central nervous system in the propagated sensation experienced by the mock laser participants [9,21,59,60]. In contrast, some researchers suggest that fine nerve fibers, such as A $\delta$  and C fibers, are essential in the process and development of PSC [3,8,14]. Similar to De Qi, PSC might be a central phenomenon of bodily self-awareness and consciousness [58,61,62]. The perception of migratory sensations may reinforce the patients’ belief in the acupuncture theory that is postulated to mobilize stagnated Qi [46], plus the belief about the importance of reporting bodily sensations owing to body awareness and self-consciousness [63], may partially explain the PSCs reported by the participants receiving the mock laser. It is therefore possible that the interaction between the psychological state and the physiological changes due to the administered interventions facilitates a positive clinical response [46].

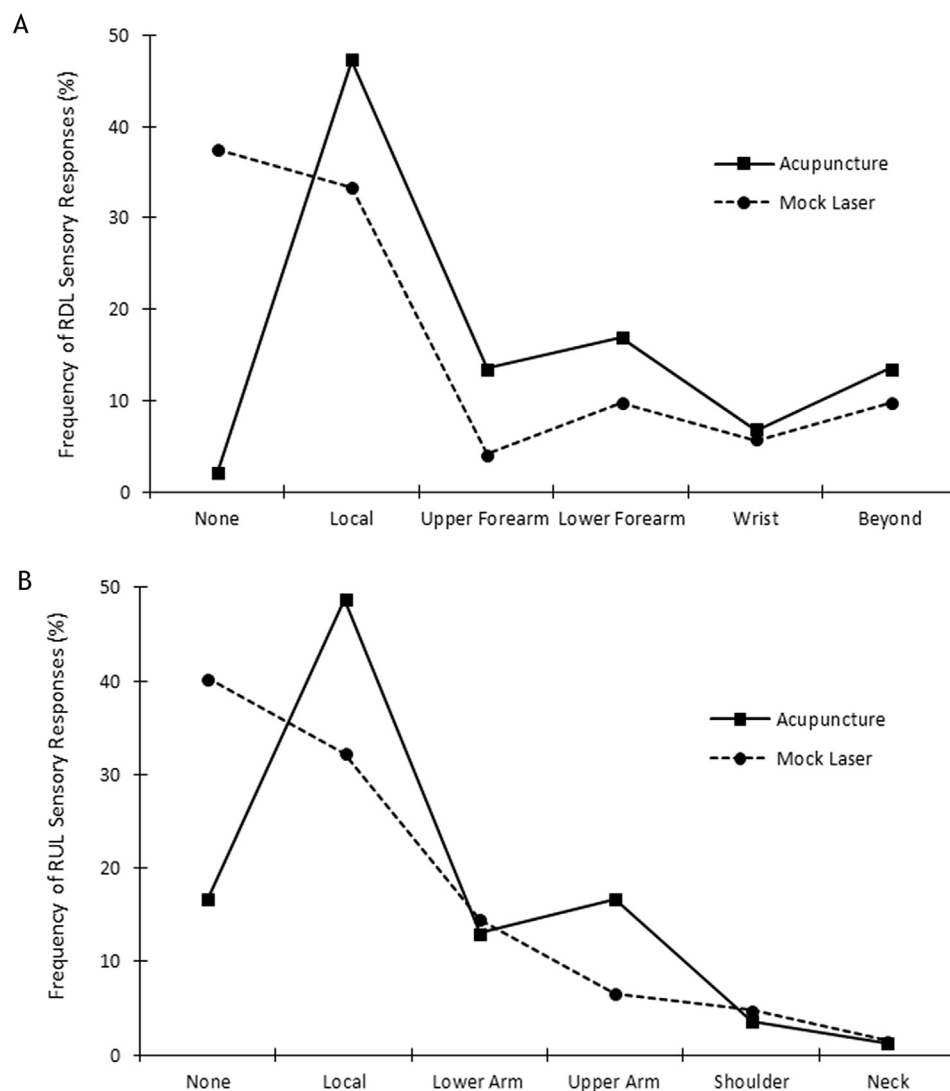
When the rate of occurrence for both RDL and RUL between the two interventions were compared, “None” and “Local” in the control group, “local” and “lower forearm/upper arm” in the treatment group were identified as the first and second most frequently reported radiation sites. The results from our study are similar to a previous study that also reported radiating patterns for acupuncture stimulus extended beyond the needling site, whereas those for tactile stimulation remained local [64].

As explained earlier, PSC such as De Qi have a long tradition in acupuncture research; however, very few attempts have been made to separate the two phenomena. One possible reason is that there is little emphasis on PSC compared to obtaining De Qi, as part of achieving treatment efficacy. This could be because in the acupuncture literature, PSC is prevalently considered to be another feature of the De Qi psychophysical response [6,27,32,33] frequently described as a spreading or radiation sensation [23,34–37]. In several studies, De Qi is often characterized as a composite of unique psychophysical responses described as “Suan (aching/soreness), Ma (tingling/numbness), Zhang (fullness/distension pressure) and Zhong (heaviness)” [32,41,65–70]. It appears that the phenomenon (PSC) is inaptly embedded within another concept, De Qi. Moving forward, we feel that these two concepts should be distinguished and investigated in their own right as important phenomena.

**Table 3** Comparison of the frequency of radiating sites (RDL–RUL) among the two intervention groups.

RDL sites	Acupuncture		Mock laser		RUL sites	Acupuncture		Mock laser	
	Count	%	Count	%		Count	%	Count	%
1. None	2	2.2	27	37.5	1. None	14	16.7	25	40.3
2. Local	42	47.2	24	33.3	2. Local	41	48.8	20	32.3
3. Upper forearm	12	13.5	3	4.2	3. Lower arm	11	13.1	9	14.5
4. Lower forearm	15	16.9	7	9.7	4. Upper arm	14	16.7	4	6.5
5. Wrist	6	6.7	4	5.6	5. Shoulder	3	3.6	3	4.8
6. Beyond	12	13.5	7	9.7	6. Neck	1	1.2	1	1.6
Fisher's exact test	$p = 0.000^{\dagger}$				$p = 0.013^*$				

Frequencies calculated upon the number of participants reporting perception of radiating response within each study groups. Expected frequencies were less than five in some cells, and therefore Fisher exact test was displayed, \* $p < 0.05$ ,  $^{\dagger}p < 0.001$ . RDL = radiating down limbs; RUL = radiating up limbs.



**Figure 2** (A and B) Comparison of the frequency of radiating/spreading sensory responses down and up the limb (RDL and RUL, respectively), demonstrating different radiating sites reported on the affected limb both during acupuncture and mock laser intervention. Data for sessions 1 and 9 were pooled together. RDL = radiating down limbs; RUL = radiating up limbs.

**Table 4** Comparison of radiation sites across the trial centers in each study group; treatment and control.

Radiating sensation	Radiation sites	Acupuncture								Mock laser				Fisher's exact test					
		HK		AUS		CHA		ITY		HK		AUS		ITY		Acupuncture		Mock laser	
		<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	$\chi^2_{Acup.}$	<i>p</i>	$\chi^2_{Laser}$	<i>p</i>
RDL	1. None	0	0	2	8.3	0	0	0	0	13	56.5	14	60.9	0	0	46.39	0.000*	44.01	0.000*
	2. Local	4	18.2	6	25.0	17	73.9	15	75.0	3	13.0	1	4.3	18	75.0				
	3. Upper forearm	1	4.5	2	8.3	4	17.4	5	25.0	1	4.3	0	0	2	8.3				
	4. Lower forearm	6	27.3	7	29.2	2	8.7	0	0	2	8.7	3	13.0	2	8.3				
	5. Wrist	3	13.6	3	12.5	0	0	0	0	1	4.3	2	8.7	1	4.2				
	6. Beyond	8	36.4	4	16.7	0	0	0	0	3	13.0	3	13.0	1	4.2				
RUL	1. None	4	21.1	7	29.2	2	9.5	1	5.0	8	50.0	16	72.7	1	4.2	20.86	0.064	47.09	0.000*
	2. Local	7	36.8	12	50.0	15	71.4	7	35.0	1	6.3	1	4.5	18	75.0				
	3. Lower arm	4	21.1	2	8.3	2	9.5	3	15.0	2	12.5	5	22.7	2	8.3				
	4. Upper arm	4	21.1	2	8.3	2	9.5	6	30.0	3	18.8	0	0	1	4.2				
	5. Shoulder	0	0	0	0	0	0	3	15.0	2	12.5	0	0	1	4.2				
	6. Neck	0	0	1	4.2	0	0	0	0.0	0	0	0	0	1	4.2				

\**p* < 0.001.

AUS = Australia; CHA = China; HK = Hong Kong; ITY = Italy; RDL = radiating down limb; RUL = radiating up limb.

In general, participants in both study groups reported radiating sensations a greater distance distally down the forearm to the wrist and beyond compared to a radiating sensation proximally up the arm to the shoulder and beyond. Many researchers frequently acknowledged that arrival of PSC, namely, Qi, traveling along the channel toward the pathological site being treated can have a therapeutic effect [1,10,11,18,29,30]. Such studies have been investigated for the following conditions: coronary heart disease [71], myopia in young children [72], relief of vascular tension and muscle convulsion in cervical vertebra disease [73], promoting blood circulation and removal of blood stasis [74], and facial disease [75]. Although in our study, there was no obvious reason why RDL was reported a greater distance distally down the wrist, one study noted the running route of PSCs on the limbs was in conformity with classic meridians [2]. Another study also stated that puncturing an acupoint midway along a meridian simultaneously travels both directions to the beginning and end of the stimulated meridian [17].

The nature of migratory sensations either proximally up or distally down the arm was not within the scope of the study—hence, it was not investigated. Participants in each study group selected significantly different radiating sensation sites downward the limb across the four trial sites, whereas radiating sensation sites proximally up the limb was significantly different only for the mock laser group among the four trial sites. Although results from a survey on PSC revealed no differences in properties of PSC among races [56], the result of our study suggests that people with dissimilar cultural background may perceive PSC and their related propagated sites differently. Likewise, one study showed that Chinese patients perceived acupuncture sensory responses as migratory rather than static [46], yet PSC is considered a universal phenomenon in human beings [1].

One research study has suggested that the phenomenon of PSC is different from that of De Qi in that De Qi is a subjective feeling [2], whereas PSC is regarded as an objective response [28] that can be detected and traced

using sophisticated devices on the meridian [17]. Several studies have used different methods and devices to study PSC such as photonic technology [76], infrared thermal imaging [28], surface electromyography [2], photoluminescence of bioceramic [77], bodily sensation maps [64], as well as a Geographic Information System [6]. The investigation of PSC has been limited by a lack of appropriate methods and devices for its assessment [6].

## 5. Limitation and suggestion for future research

One of the limitations of the study was that the mock laser was not truly inert. The laser probe physically touched the skin surface at the two classical acupoints for 2 minutes. Weak mechanical stimuli (light touch) of the skin stimulates mechanoreceptors associated with slow conducting unmyelinated C afferents [78–81.] and this may have provoked activity in the insular region of the brain leading to a sensual “limbic touch” response inducing emotional and hormonal reactions [79,82]. For future studies, it is therefore suggested to provide an adequate distance between skin and laser probe to prevent skin tactile stimulation.

Additionally, nonspecific effects such as participant's expectancy [58,83–85], previous acupuncture experience [84], focus (e.g., visual attention) [58,63], and general treatment settings [58] may all have a significant influence in the perception of De Qi.

Another drawback of the study was that although all attempts were made to standardize the acupuncture technique, no analysis was undertaken to determine if statistically different scores were obtained from the comparison of occasions when different acupuncturists at each of the four sites administered the needling.

Finally, several researchers have developed placebo controls to control for the psychological impact of needling while reducing the therapeutic and nonspecific effects of needling [86]. A variety of control interventions have been applied in acupuncture clinical trials owing to individual

body physiognomies and body complexity [87]; however, their impact on the neurological brain response has not been well appraised using functional brain images [86].

Some researchers also suggest recruiting naïve participants to further investigate the interoceptive response during acupuncture needling. The result from one study showed that patients with previous experience of acupuncture were more likely to report the needling sensation as migratory compared to the acupuncture-naïve patient [46]. Future research therefore should investigate the impact that a patient's beliefs, expectations, and interoceptive awareness could have on the perception of PSC.

## 6. Conclusion

The sensory components of acupuncture, namely, De Qi and PSC, are complex and difficult to study as they are influenced by a variety of factors. Further research into the phenomenon is warranted to investigate the role of PSC despite the lack of morphological evidence for the existence of the channels.

Given that PSC are postulated to be necessary to enhance acupuncture efficacy, it is essential to develop appropriate methods for PSC assessment. Increasing research into interoception may contribute to a better understanding of the placebo effect and its psychophysical responses that are often observed in the administration of a placebo intervention in a controlled trial.

## Disclosure statement

The authors declare that they have no competing interests. No competing financial or non-financial interests from funding sources.

## Acknowledgments

MG was supported by the UGC's Hong Kong PhD fellowship scheme 2013/14 (PF12-16701). This study was partially supported by the Hong Kong Baptist University faculty research grants to SPZ (FRG1/14-15/056); by the National Institute of Complementary Medicine (NICM), Australia to CZ; and by the National Basic Research Program of China (973 Program), No. 2014CB543101.

## Availability of data and materials

All data were managed and are kept at the University of Technology Sydney, Australia. Duplicate data are also kept at the Hong Kong Baptist University.

## Authors' contribution

All authors conducted the trial and collected the data. SR, CZ, MG and SPZ drafted the manuscript. All authors critically revised and approved the final manuscript. CZ, SPZ, FCW, CB, WHL, MG, LT designed the original the study. SR analyzed the data and was the main author. FCW, CZ, SPZ,

SB, were the study trial coordinator at the four sites. MH was statistical advisor.

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