

EFFECT OF ELECTROACUPUNCTURE AND TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION AT HEGU (LI.4) ACUPUNCTURE POINT ON THE CUTANEOUS REFLEX

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ABSTRACT:

Our previous studies have shown that the cerebral cortex plays a modulator role in the physiological mechanisms of acupuncture and 2Hz electroacupuncture (EA), but either acupuncture or 2Hz EA appeared to have very little effect on spinal cord. However, 2Hz or 100Hz transcutaneous electrical nerve stimulation (TENS) applied to Hegu acupuncture point (LI.4) can increase the amplitude of the H-reflex, whereas manual acupuncture has no similar effect. Therefore, the aim of the present study was to further investigated the effect of 2Hz EA, 2Hz or 100Hz TENS on cutaneous reflex (CR). A total of 13 healthy adult volunteers were studied. CR recordings were obtained on the right first dorsal interosseous muscle by electrical stimulation of the ipsilateral index finger. 2Hz EA, 2Hz or 100Hz TENS was applied to the surface of the left LI.4, and then the changes of CR were observed. The results indicated that CR was characterized by an initial short latency excitatory wave (E1), followed by an inhibitory wave (I1), then a long latency excitatory wave (E2). Both 2Hz EA and 2Hz TENS applied to the surface of the left LI.4 could prolong the latencies of I1 component of CR, whereas 100Hz TENS has no similar effect. In addition, either EA or TENS could not change the latencies of E1, E2 component and the amplitudes of I1, E2 component of CR. In conclusion, 2Hz EA or 2HzTENS applied to the

L1.4 prolonged the latencies of I1 component of CR, suggesting that the action site of 2Hz EA or 2Hz TENS located in the supraspinal, possibly in the subcortical or cortical level. In addition, the electrical stimulation of higher frequency such as 100Hz TENS acting on CR caused habituation easier.

Key words: Cutaneous reflex, Electroacupuncture, Transcutaneous electrical nerve stimulation, 2Hz, 100 Hz.

INTRODUCTION

Our previous studies find that the cerebral cortex participates and plays a modulator role in the physiological mechanisms of acupuncture and 2Hz electroacupuncture (EA) [1,2]. In addition, 2 Hz EA applied to the Zusanli acupuncture point (St.36) cannot change the R1 component of the blink reflex or soleus H-reflex, but it can depress the R2 component of the blink reflex that contralateral to stimulus site [3], suggesting that EA has no effect on monosynaptic reflexes in the brain stem or spinal cord, but it can change polysynaptic reflex in the brain. There are different effects between transcutaneous electrical nerve stimulation (TENS) and EA on blink reflex has been reported [4], and the stimulation at different frequencies is mediated via different mechanisms in the central nervous system [5,6]. In addition, our previous results indicated that 2Hz and 100Hz TENS applied to L1.4 increased the amplitude of the H-reflex, and theses effect are greater in 100 Hz than 2Hz, whereas manual acupuncture (MA) is no similar effect, suggesting different physiological action mechanism among TENS, EA and MA [7].

Cutaneous reflex (CR) recordings can be obtained on the first dorsal interosseous muscle by the electrical stimulation of the ipsilateral index finger. In general, CR was characterized by an initial short latency excitatory wave (E1), followed by an inhibitory wave (I1), then a long latency excitatory wave (E2) [8,9]. The E1 component of CR is considered that is a spinal origin, while the I1 component of CR is modulated by supraspinal mechanism probably originated subcortically [10]. The E2 component of CR is of supraspinal origin requiring transmission of sensori-motor and descending pyramidal tract [11]. Because CR includes both afferent and efferent components of central nervous system, and it has been used to be a functional index for the central nervous system [11,12,13][Fig. 1].

The aim of the present study was to further investigate the effect of EA and TENS. CR recordings were performed on right first dorsal interosseous muscle by electrical stimulation of the ipsilateral index finger. 2Hz EA, 2Hz or 100Hz TENS was applied to the surface of the left first dorsal interosseous muscle exactly at L1.4, respectively. The latencies and amplitudes of each component of CR were measured.

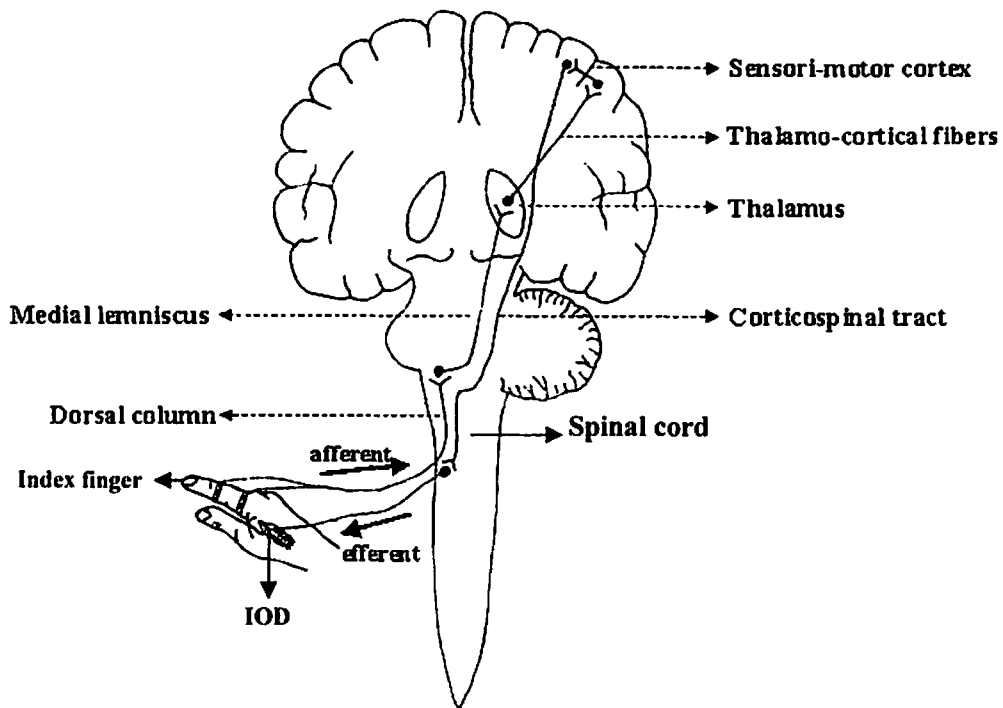


Fig 1. Schematic presentation of afferent and efferent pathways of cutaneous reflex (CR) recorded from the first dorsal interosseous muscle (IOD). The transmission of afferent impulses elicited by the electrical stimulation of the ipsilateral index finger is through the sensory nerves, dorsal columns, the medial lemniscal pathway, thalamus and relay in sensory-motor cortex, then descending transmission to form the reflex circuitry by way of the corticospinal tract.

MATERIALS AND METHODS

Subjects

13 healthy adult volunteers (9 female, 4 male) were studied, their age between 22 to 34 years (mean $\pm$ S.D., 26 ± 4). Clinical examination revealed no neurological abnormalities in all of them. The experimental procedures were fully explained to the subjects, and informed consent was obtained prior to the experiment. At the time of the experiment, subjects were asked to refrain from taking any pharmacologically active substances including drugs, alcohol and caffeine, or receiving other treatments of acupuncture or TENS beyond the experiment. The experiments were performed in a semi-illuminated quiet room with a consistent temperature of 24-26°C. During the experiment, each subject was awake and relaxed, seated comfortably with right forearm supported by a splint on a table. The distance from middle finger to the seventh cervical spine was measured in a 45° abduction of the arm to normalize the latencies of reflex components.

Electrodes preparation

The surface electrode over the belly of the right first dorsal interosseous muscle served as an active electrode. The reference electrode was placed over the right styloid process of the radius. The ground electrode was placed on the dorsum of right hand between 4th and 5th phalanx. The skin-electrode impedance was below 10 K Ω . Skin temperature was maintained at above 31°C.

Stimulus

Square-wave electrical pulses (0.2ms in duration, 3 Hz in frequency) were delivered through a pair of ring electrodes proximally (cathode) and 3cm distally (anode) to the proximal interphalangeal joint of the right index finger. The intensity of stimulus was four times the sensory threshold.

CR recordings

CR recordings were obtained using an EMG amplifier (Medelec Sapphire Premiere Plus, Oxford, UK) with a bandpass filter setting between 20 Hz and 2 KHz. The analysis time was 100 ms. 256 responses were averaged at least twice to assure reproducibility in each session. The latencies were measured from the stimulus-artifact to its peak. Normalized data of latencies was corrected by using an arm length of 100 cm [14]. The amplitudes of I1 (A1) were determined from the peak of E1 to the peak of I1, while the amplitudes of E2 (A2) were from the peak of I1 to the peak of E2 (Fig. 2).

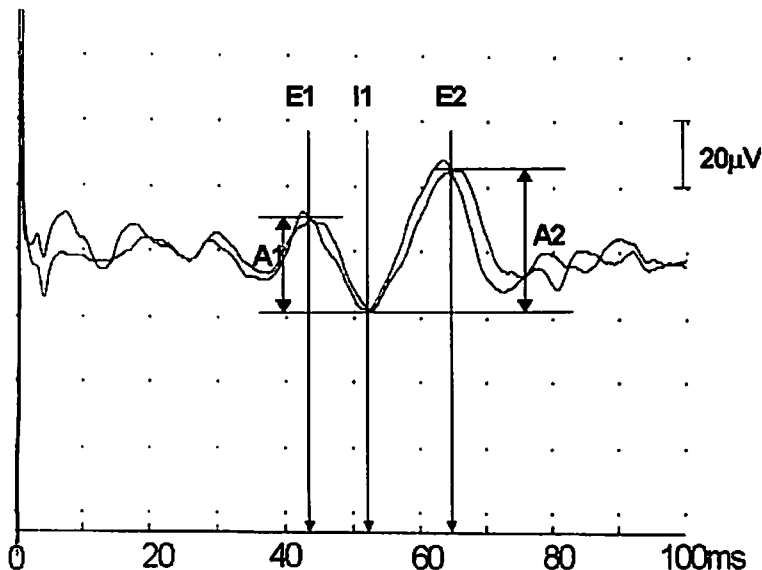


Fig 2. Cutaneous reflex recordings were obtained in the right first dorsal interosseous muscle by electrical stimulation of the ipsilateral index finger in a 34-year-old male. The characteristics are an initial short latency excitatory wave (E1), followed by an inhibitory wave (I1), then a long latency excitatory wave (E2). The latencies of E1, I1 or E2 were determined from stimulus artifact to the peak. The peak to peak amplitudes of E1-I1 (A1) and I1-E2 (A2) were measured at the arrows. The analysis time was 100 ms.

Experimental procedure

The subjects were instructed to perform a steady isometric contraction of the first dorsal interosseous muscle at 20% maximal force by abducting the index finger against a force transducer. The constant force was maintained with the visual feedback aided by digital voltmeter displaying the EMG level.

A battery- powered portable stimulator (H.A.N.S.; Han's Acupoint Nerve Stimulator, LY-257, Wearnes Automatic Pte. Ltd. Singapore, with bi-directional symmetric square waveforms, wave widths 0.2ms at 100 Hz and 0.6 ms at 2 Hz) was used to produce TENS. TENS was delivered via two 3.5*5cm disposable electrodes. One was placed at the surface of the left LI.4 located at the dorsum of the left first dorsal interosseous muscle, and another electrode was placed on the palm of the left hand (Fig. 3,4).

Four assessments were performed randomly in all the subjects as follows: 1) Control assessment: a pair of electrodes was placed on the surface of the left LI.4, but no electrical stimulation was delivered throughout the test; 2) 2Hz TENS assessment: electrical stimulation at 2Hz (30 mA in intensity) was applied to the surface of the left LI.4; 3) 100Hz TENS assessment: electrical stimulation at 100Hz (10mA in intensity) was applied to the surface of the left LI.4; 4) EA assessment: two acupuncture needles (sterile stainless needle, 1 inch in length) were inserted into left LI.4 and the point 0.5 cm proximally. 2Hz bi-directional symmetric square pulses were applied using the stimulator between the two adjacent needles after twisting with fingers to obtain a so-called De-qi sensation. The interval between assessments was at least one week to prevent any residual effects of intervention. Each assessment was divided into three periods as follows: 1) Baseline period (BP): the baseline CR recordings were established prior to TENS or EA stimulation; 2) stimulus period (SP): following the BP, 2Hz TENS, 100Hz TENS or 2 Hz EA was applied to the left LI.4 for 10 min. CR recordings were obtained 5-10 minutes after the start of stimulation; 3) Post-stimulus period (PP): CR recordings were obtained 5-10 minutes after the stimulation stopped.

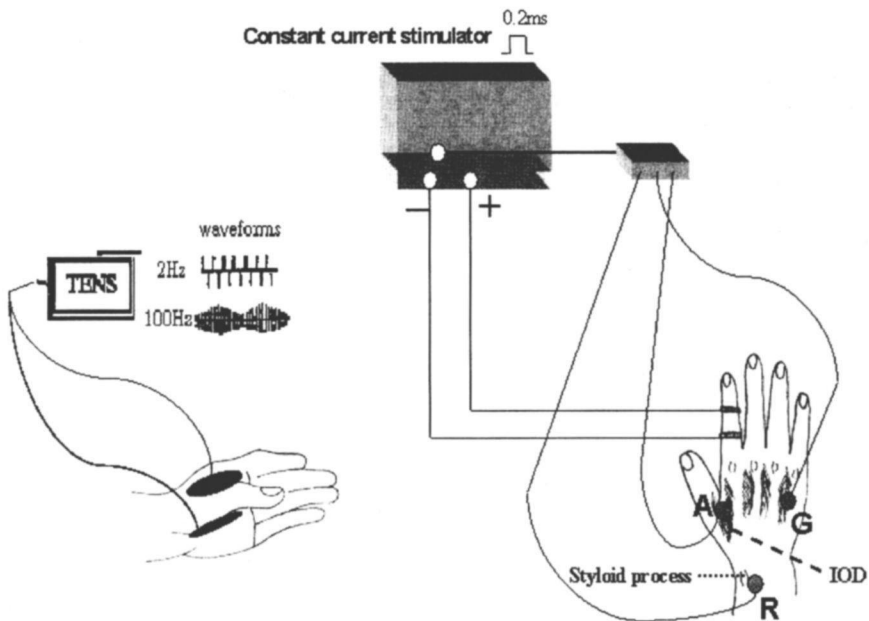


Fig 3. Representation of the cutaneous reflex recordings and the transcutaneous electrical nerve stimulation. The positioning of the stimulator ring electrodes was shown. -: cathode, +: anode. The first dorsal interosseus muscle (IOD) is located between the thumb and the index finger. Recording of the averaged compound action potential was made via surface electrodes (filled circles): A (active electrode); R (reference electrode); G (ground electrode).



Fig 4. Actual photo of the experimental subject and the instrument. Subjects were seated with the forearm supported by a splint.

Statistical analysis

The data were presented as mean $\pm$ S.D. One-way ANOVA for repeated measures was used to determine the presence of a statistical difference in the latency and amplitude of the CR data among the various periods in the four assessments of the same individuals. Scheffe's post hoc procedure for pairwise comparisons was used to determine pairwise differences among the four assessments (SAS v6.12 software, SAS Institute Inc., SAS Campus Drive, Cary, NC) [15]. A *p* value less than 0.05 is considered to be statistically significant.

RESULTS

CR recordings were obtained from the surface over the belly of the right first dorsal interosseous muscle evoked by the electrical stimulation of the ipsilateral index finger in all 13 subjects. The CR was characterized by an initial up deflection short latency excitatory wave (E1), followed by a down deflection inhibitory wave (I1), then a up deflection long latency excitatory wave (E2) (Fig. 1).

Effect of TENS and EA on the latencies of the E1 component of CR

The latencies of E1 component of CR were no change during 2Hz or 100Hz TENS, or 2Hz EA applied to the left LI.4 (all *P* > 0.05, Fig. 4, Table 1).

Table 1. Effect of TENS and EA on the latencies of E1 component of cutaneous reflex (ms)

	Absolute latency			Normalized latency		
	BP	SP	PP	BP	SP	PP
Control	38.96 $\pm$ 1.43	38.86 $\pm$ 1.33	39.42 $\pm$ 1.42	43.97 $\pm$ 2.40	43.87 $\pm$ 2.46	44.48 $\pm$ 2.10
2Hz	39.40 $\pm$ 2.05	40.73 $\pm$ 2.08	40.82 $\pm$ 2.43	44.49 $\pm$ 3.14	45.96 $\pm$ 2.75	46.10 $\pm$ 3.69
100Hz	40.14 $\pm$ 2.08	39.56 $\pm$ 1.51	40.42 $\pm$ 2.51	45.29 $\pm$ 2.64	44.63 $\pm$ 2.01	45.60 $\pm$ 3.01
EA	38.86 $\pm$ 1.53	39.39 $\pm$ 1.98	39.68 $\pm$ 2.35	43.84 $\pm$ 2.11	44.46 $\pm$ 2.83	44.82 $\pm$ 3.62

Abbreviations: This and subsequent tables

Control= no electrical stimulation; 2Hz= 2Hz TENS applied to left LI.4; 100Hz= 100Hz TENS applied to left LI.4; EA= 2Hz electroacupuncture applied to left LI.4; BP= cutaneous reflex recordings during the period of baseline; SP= cutaneous reflex recordings during the period of stimulus; PP= cutaneous reflex recordings during the period of post-stimulus. The values were presented as mean $\pm$ SD. Normalized latency: adjustment of arm length to a standard of 100cm

Effect of TENS and EA on the latencies of the I1 component of CR

The latencies of baseline were similar among the four assessments (all *P* > 0.05, Table 2). The latencies of I1 component of CR were significantly different between baseline and stimulus period (*P* < 0.05, *P*=0.0003). Both 2Hz TENS and 2Hz EA applied to the left LI.4 prolonged the latencies of the I1 component during the period of stimulus (*P* < 0.05, Table 2, Fig.4), and these changes were maintained until the period of post-stimulus (*P* < 0.05, Table 2, Fig.4). The latencies of I1 component of CR were no changes in 100Hz TENS assessment (*P* > 0.05, Table 2, Fig.4).

Table 2. Effect of TENS and EA on the latencies of I1 component of cutaneous reflex (ms)

	Absolute latency	Normalized latency
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	BP	SP	PP	BP	SP	PP
Control	46.07±2.20	45.94±2.01	46.27±2.30	51.96±2.39	51.82±2.38	52.19±2.58
2Hz	46.10±2.58	47.45±2.57*	47.60±2.64*	51.98±2.69	53.52±2.88	53.70±3.30
100Hz	46.11±2.57	46.17±2.75	46.60±2.77	52.01±2.87	52.06±2.85	52.56±3.12
EA	45.57±2.19	46.79±2.03*	47.47±1.85*	51.40±2.63	52.82±3.18	53.56±2.49

Mean ± SD. *p < 0.05 compared with the values of BP

Effect of TENS and EA on the latencies of the E2 component of CR

The latencies of E2 component of CR were no change during 2Hz or 100Hz TENS, or 2Hz EA applied to the left LI.4 (all P > 0.05, Fig. 4, Table 3).

Table 3. Effect of TENS and EA on the latencies of E2 component of cutaneous reflex (ms)

	Absolute latency			Normalized latency		
	BP	SP	PP	BP	SP	PP
Control	58.40±4.39	58.28±4.22	58.52±3.98	65.89±5.22	65.80±5.73	66.07±5.60
2Hz	57.37±3.15	58.95±4.36	59.37±4.46	64.78±4.98	66.55±5.87	67.04±6.10
100Hz	57.29±3.08	57.81±3.14	58.10±3.73	64.64±3.90	65.25±4.48	65.55±4.46
EA	56.94±3.34	58.29±2.77	58.68±3.32	64.27±4.55	65.80±4.34	66.20±3.94

Mean ± SD.

Effect of TENS and EA on the A1 amplitudes of CR

The A1 amplitudes of baseline were similar among the four assessments (P>0.05). The A1 amplitudes of CR were not significantly different among the period of BP, SP and PP, or among the four assessments_all P > 0.05, Table 4_.

Table 4. Effect of TENS and EA on the A1 amplitudes of cutaneous reflex (μV)

	BP	SP	PP
Control	24.42±10.75	23.95±10.42	23.24±9.69
2Hz	19.26±6.38	21.75±8.58	23.13±11.70
100Hz	21.05±6.75	21.87±7.63	23.21±9.78
EA	22.15±10.41	21.92±11.37	21.69±9.29

Mean ± SD.

Effect of TENS and EA on the A2 amplitudes of CR

The mean A2 amplitudes were similar among the four assessments during BP (P>0.05). The A2 amplitudes of CR were not changed during 2Hz or 100Hz TENS, or 2Hz EA applied to the left LI.4_all P > 0.05, Table 5_.

Table 5. Effect of TENS and EA on the A2 amplitudes of cutaneous reflex (μV)

	BP	SP	PP
Control	40.57±12.63	39.41±14.40	39.32±15.39
2Hz	37.99±11.94	40.32±14.80	43.48±18.01
100Hz	37.29±10.19	38.35±13.12	40.43±12.63

EA 38.51±18.00 36.75±11.64 37.60±16.15
Mean ± SD.

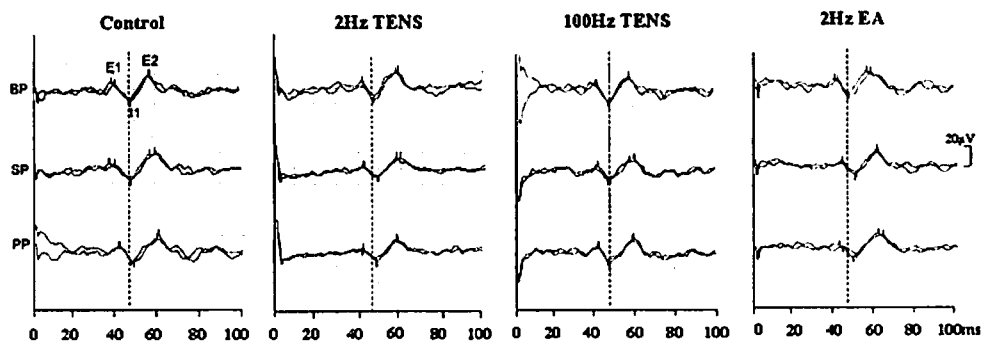
Effect of TENS on the amplitude quotient (AQ, A1/A2)

The AQ values were not significantly different among the period of BP, SP and PP, or among the four assessments_all $P > 0.05$, Table 6_.

Table 6. Effect of TENS and EA on the AQ

	BP	SP	PP
Control	0.60±0.13	0.61±0.18	0.63±0.20
2Hz	0.54±0.20	0.56±0.18	0.54±0.19
100Hz	0.57±0.17	0.59±0.16	0.57±0.16
EA	0.60±0.18	0.58±0.20	0.58±0.17

Mean ± SD.



LI.4; 100Hz TENS= 100Hz TENS applied to left LI.4; 2Hz EA= 2Hz electroacupuncture applied to left LI.4; BP= the period of baseline; SP= the period of stimulus; PP= the period of post-stimulus.

DISCUSSION

Our results indicate that both 2Hz TENS and 2Hz EA applied to the left LI.4 can prolong the I1 latencies of CR that recorded on the right dorsal interosseous muscle, suggesting the action site of 2Hz EA or TENS was in the supraspinal level. Because several earlier studies consider that the I1 component of CR is most likely originated subcortically and it might be modulated by a supraspinal mechanism [10,16]. The inhibitory activity brought by cutaneous afferents does not have a direct effect on the α -motoneuron nor the presynaptic terminals of the Ia afferents, therefore, suggesting that its action site is above the α -motoneuron. The amplitudes of I1 component of CR is reduced in patients with Parkinson's disease, suggesting that the reduction of an inhibitory mechanism depending on the integrity of a subcortical catecholaminergic mechanism [10]. In addition, both I1 and E2 components of CR are absent in the damage of the motor cortex, therefore, it was thought that interneurons mediating the I1 component of the CR are normally subject to tonic facilitation from inputs whose activity is dependent upon the functional integrity of the motor cortex [11]. Several

studies consider that the I1 component of CR is mediated via a transcortical pathway [17,18]. Our previous studies have known that the cerebral cortex participates in the physiological mechanisms of acupuncture and 2Hz EA [1,2]. Together above-mentioned, we confirmed that the I1 component of CR is a supraspinal origin, possible in the subcortical or cortical level.

The CR is a spinal or a transcortical polysynaptic reflex, and it can be influenced by a supraspinal impulses. Several earlier studies find that CR can be change by the lesions of the ipsilateral dorsal columns, corticospinal tract, or the contralateral sensori-motor cortex, but it is not affected by the lesions of the frontal lobe, occipital lobe, cerebellum or spinothalamic pathways [11,12,19]. The E2 component of CR involved the activity in the dorsal columns, sensori-motor cortex and the corticospinal tract has been demonstrated [11]. Abnormal I1-E2 components of CR were observed in patients with pure sensory lacunar infarctions corresponding to thalamic lesions, these evidences supported that the supraspinal origin of I1-E2 components of CR required the transmission of afferent impulses through such routes as the dorsal columns, the medial lemniscal pathway and a thalamic relay [16].

The results of the present study indicate that neither of 2Hz EA, 2Hz or 100Hz TENS could change the E1 components of CR. These results are similar to our previous findings that 2Hz EA applied to Zusanli acupuncture points (St.36) cannot change spinal component of median nerve-somatosensory evoked potentials [1], and also cannot change the R1 component of the blink reflex or soleus H-reflex [3]. The latency of E1 component of CR is similar to that of the H-reflex and a central delay of 4.6ms, thus it is considered as a spinal origin [20]. It remains unclear, why 100 Hz TENS had no effect on the I1 component of CR in the present study. These results may be explained by an earlier study that the habituation phenomenon of CR is easier developed by a longer and higher frequency stimulus [21].

In conclusion, 2Hz EA or 2Hz TENS applied to the LI4 prolonged the latencies of I1 component of cutaneous reflex, suggesting that the action site of 2 Hz EA or 2Hz TENS is in the supraspinal, possibly in the subcortical or cortical level. In addition, the electrical stimulation of higher frequency such as 100Hz TENS acting on CR caused habituation easier.

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