JAM
Japanese Acupuncture and Moxibustion

Original Research

Effects of Electro-acupuncture stimulation on the left–right asymmetry of lumbar erector spinae muscle EMG activity in subjects with lower back pain

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Abstract
[Objective] To examine the effects of acupuncture stimulation on the left–right asymmetry of lumbar erector spinae muscle EMG activity during trunk flexion exercises.
[Methods] 12 subjects with lower back pain (mean age: 19.8 ± 1.1 years). Assessment items were left–right asymmetry of lumbar erector spinae muscle EMG activity during trunk flexion (% difference) and the degree of lower back pain [visual analog scale (VAS)]. Acupuncture was performed as an intervention for the left–right lumbar erector spinae muscles (L4 and L5) with an electrical stimulus of 1 Hz for 10 min.
[Results] The mean % difference in lumbar erector spinae muscle EMG activity was 31.1 ± 2.9% before acupuncture stimulation and 18.3 ± 2.4% after acupuncture stimulation, which was a significant decrease ($P < 0.05$). The mean VAS score was 32.3 ± 5.2 mm before acupuncture stimulation and 24.2 ± 5.6mm after acupuncture stimulation, which was also a significant decrease ($P < 0.05$).
[Conclusion] Our results suggest that acupuncture stimulation is effective for left–right asymmetry remission of lumbar erector spinae muscle EMG activity during trunk flexion and can alleviate lower back pain.

Key words: *acupuncture, % difference, lower back pain, erector spinae muscle*

I. Introduction

Lower back pain is a common affliction in normal adults with an incidence of 85%–95%[1)]. Only 2% of subjects with lower back pain have indications for surgical treatment[2,3)]. Therefore, conservative therapies are important for the treatment of lower back pain. Among the conservative therapies, acupuncture has been reported to have immediate as well as sustained effects for relieving pain and recovering functional impairments[4-6)]. The sustained effects are reported to last for several months[5-7)].

From the 1950s, several researchers performed surface electromyographic (EMG) studies in subjects with lower back pain and found that most of them showed characteristic EMG activity in the lumbar erector spinae muscle during gradual trunk flexion[8-14)]. In ordinary subjects without lower back pain, significant EMG activity of the erector spinae muscle at the beginning of trunk flexion disappears with the progress of gradual flexion. This is known as the flexion–relaxation phenomenon[8,9)]. In most subjects with lower back pain, the erector spinae muscle of the painful side maintains activity during the whole process of flexion, resulting in the left–right asymmetry of EMG activity in the erector spinae muscle[10-12)]. This maintained muscle activity during flexion may be closely associated with the lower back pain. The excessive tension in the muscle may be the cause of pain or the defense mechanism against pain may excessively activate the muscle.

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The asymmetry of EMG activity in the erector spinae muscle is, however, not specific in subjects with lower back pain. A considerable number of subjects without lower back pain demonstrate asymmetry of EMG activity in the erector spinae muscle as well[15]. On the other hand, some subjects with lower back pain do not show this asymmetry[14,17].

Tanaka et al.[15] evaluated 30 healthy individuals and found 10 subjects with significant left–right asymmetry in EMG of the erector spinae muscle. They found marked decrease of the asymmetry with acupuncture treatment. However, in previous studies, it has not been clarified the effects of acupuncture stimulation on the left−right asymmetry of lumbar erector spinae muscle EMG activity in subjects with lower back pain. Left−right asymmetry may lead to an imbalance in the spine, thereby increasing the risk of lower back pain. Furthermore, if the asymmetry is closely associated with lower back pain, those subjects without lower back pain would be at risk of developing lower back pain and therefore, require some preventive treatment. In our hypothesis is that the pain and the asymmetry of EMG activity of an erector muscle of spine after stimulation are related, If the % difference in the left–right asymmetry and the degree of lower back pain decreased after acupuncture stimulation.

This study aimed to examine the relationship between EMG asymmetry and the intensity of lower back pain through the correlation of acupuncture effect.

Ⅱ. Materials and Methods

1. Subjects

We evaluated 12-male college students who complained of lower back pain (mean age: 19.8 ± 1.1 years; mean height: 174.8 ± 5.7 cm; mean weight 67.8 ± 6.0 kg). None of these subjects had been previously diagnosed with organic diseases such as spondylolysis or lumbar disc herniation. In an advanced interview, all subjects is a member of the soccer club, most subjects experienced lower back pain during practice or after sports practice in a competition. Roland–Morris Disability Questionnaire (RDQ) of these subjects was 1.8 ± 1.4 point. RDQ is a scale that allows subjects themselves to assess the degree of disability experienced during daily activities as a result of lower back pain. It was not a situation in which the subjects' quality of life declined significantly.

This study was conducted with the approval of the ethics committee of Tsukuba University of Technology. We thoroughly explained the purpose of our research to the subjects before the trials and obtained their written consent.

2. Experimental procedure

The subjects were made to perform trunk flexion in the standing position and lumbar erector spinae muscle-EMG activity was measured with surface electrodes. Subsequently, acupuncture stimulation was performed on the corresponding parts of the lumbar erector spinae muscles (fourth and fifth lumbar spinous process supraversion) and the muscle EMG activity was again measured after the procedure. Moreover, we assessed the changes in the degree of lower back pain before and after acupuncture stimulation using a visual analog scale (VAS).

3. Measurement and assessment

1) EMG activity

(1) Recording

The study protocol was designed according to Donaldson et al.'s research[14]. Measurement sites included the left and right lumbar erector spinae muscles. The electrode was placed at the forward-facing muscle protrusions on the anterior superior iliac spine. Furthermore, they were placed parallel to the muscle bellies of the measurement sites. At the electrode attachment sites, sebum was removed with alcohol-soaked cotton wool, and any body hair was removed. A special double-sided tape was used between the electrodes and skin, and the electrodes were covered and fixed with an elastic tape. Grounding electrodes were placed on the subjects' right wrist joints.

The subjects were made to spread their legs to shoulder width and move from a standing position to the maximum flexion position while holding both knees in the extension position for 5 s each time in time with a metronome. The left–right lumbar erector spinae muscle-EMG activity was measured during this time. These measurements involved the same motion performed thrice in succession between each motion. EMG activity measurements used a surface EMG (EMG measurement system, Biometrics Co., Ltd., the United Kingdom).

The sequence of trunk flexion motions was demonstrated in advance by a research assistant, and the subjects were allowed sufficient practice. The motions were only performed once the left and right inclinations were removed, and the speed was verified. The sequence of motions was filmed from a lateral position using a fixed video camera 5 m away during the erector spinae muscle-EMG activity measurements. These measurements were used to verify motions after the experiment.

(2) Data analysis

Data were imported to a personal computer from an amplifier and integrated bipolar electrodes (electrode diameter = 10 mm; 20 mm between the electrodes) through an eight-channel relay box and analog-to-digital (AD) converter.

EMG activity was recorded as AD converted at a sampling frequency of 1000 Hz; motion artifact elements

were removed from the recording waveform with a band-pass filter (20–400 Hz), and a full-wave rectification was performed. The data were averaged over a 250ms period.

The maximum integrated EMG amplitude (absolute EMG) during the movement was recorded by the computer for both the sides. The lumbar erector spinae muscle's absolute EMG low-side reading, recorded during the trunk flexion motions, was subtracted from the high-side reading (Fig. 1). This reading produced an absolute difference, which was then divided by the high-side reading to produce a % difference[14,15]. The data analysis used the average values of the % differences between three respective recordings[5]. These data were analyzed using the TRIAS system (DKH Co., Ltd., Japan).

2) VAS

The degree of lower back pain was assessed using a 100mm VAS. The left end indicated no pain (0 mm), whereas the right end indicated pain as bad as it could possibly be (100 mm). These assessments were performed before and after acupuncture stimulation.

4. Acupuncture stimulation procedure

In acupuncture practice, stimulation is applied to muscle layers corresponding to the lumbar erector spinae muscles and lumbar spine points (Jiaji; EX-B2) commonly affected due to the lower back pain, i.e., the fourth (L4) and fifth lumbar spinous processes (L5) as well as both linear sides of the left and right spinous processes. In our study, had used pre-sterilized disposable acupuncture needle (0.2mm diameter, 60mm length, SEIRIN Co., Ltd., Japan). The acupuncture needle was inserted until it reached the muscle center (at a depth of approximately 3 cm). An electric current was then applied at a frequency of 1 Hz to each upright muscle using a low-frequency electrical device (Ohm Pulser LFP-4000A, Zeniryoki Co., Ltd., Japan). After verifying that the muscles were in twitch, they were stimulated for 10 min.

5. Statistical analysis

Attributes of the subject are expressed as mean ± standard deviation. Results are expressed as mean ± standard error. A paired t-test was used to compare the % differences in the lumbar erector spinae muscle-EMG activity before and after acupuncture stimulation. Wilcoxon signed-rank test was used to compare VAS scores before and after acupuncture stimulation. Spearman's rank correlation analysis was used to assess associations between EMG activity and VAS scores following acupuncture. Statistical analysis was performed using an IBM SPSS Statistics Base 18 (IBM Co., Ltd., Japan). A p-value of <0.05 was considered significant.

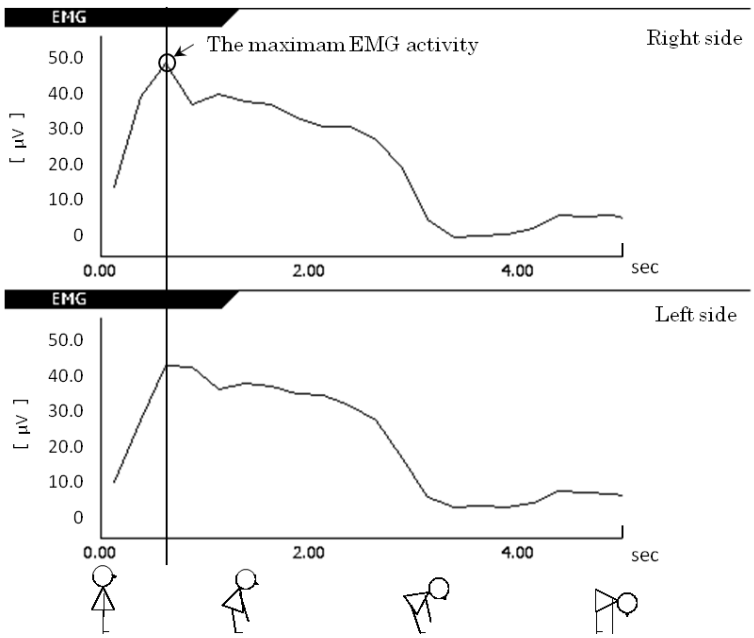

Fig.1 The subjects were then asked to move from a standing position to the maximum flexion position. We measured the left–right lumbar erector spinae muscle EMG activity during this time. To determine the % difference, the lumbar erector spinae muscle's absolute EMG low-side reading, recorded during the trunk flexion motions was subtracted from the high-side reading. This produced an absolute difference, which was then divided by the high-side reading to produce a % difference.

Table.1 The maximum absolute EMG, %difference left-right, lower back pain VAS score

	before				after			
	Right(μ V)	Left(μ V)	%difference	VAS(mm)	Right(μ V)	Left(μ V)	%difference	VAS(mm)
A	13.8	22.7	39.1	61	18.6	23.0	19.3	61
B	50.9	36.3	28.8	28	36.9	42.4	13.1	17
C	42.7	35.3	17.3	44	45.8	42.3	7.6	20
D	28.6	20.3	28.9	19	24.6	45.9	46.5	12
E	19.8	35.6	44.3	24	24.6	22.3	9.4	13
F	47.2	64.7	27.1	0	50.4	70.7	28.7	0
G	18.7	26.8	30.2	35	27.0	32.4	16.6	42
H	38.3	23.3	39.1	51	31.2	22.8	26.8	44
I	58.4	29.0	50.3	43	43.8	41.3	5.7	16
J	39.9	29.1	27.1	17	37.4	32.0	14.5	8
K	27.3	34.5	20.8	15	30.0	27.7	7.9	8
L	58.0	72.5	20	50	52.7	69.3	23.9	49

This table shows the maximum integrated EMG amplitude (absolute EMG), %difference and lower back pain VAS of each subject before and after acupuncture stimulation.

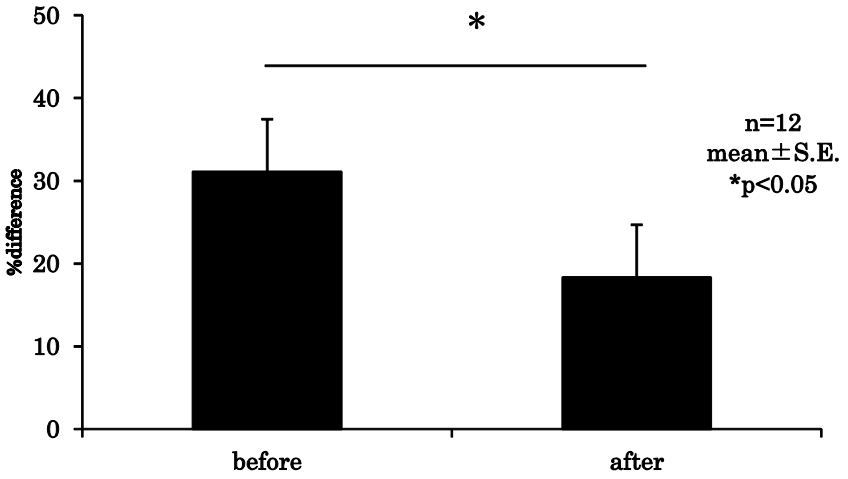

Fig.2 This figure shows the mean % difference in left–right asymmetry of acupuncture stimulation before and after. After acupuncture stimulation, the mean % difference was a significant decrease ($P < 0.05$).

Ⅲ. Results

1. % difference

The mean % difference in the left–right asymmetry was 31.1 ± 2.9% and 18.3 ± 2.4% before and after acupuncture stimulation, respectively, with a significant decrease ($P < 0.05$; Table 1, Fig. 2).

2. VAS

The mean lower back pain VAS score was 32.3 ± 5.2 mm and 24.2 ± 5.6 mm before and after acupuncture stimulation, respectively, with a significant decrease ($P < 0.05$; Fig. 3).

3. Association between EMG activity and VAS scores

No significant correlation was found between VAS value of lower back pain and EMG activity following acupuncture stimulation ($P > 0.05$; Fig.4).

Ⅳ. Discussion

Trunk flexion from a standing position is accomplished through accentuated contraction of the lumbar

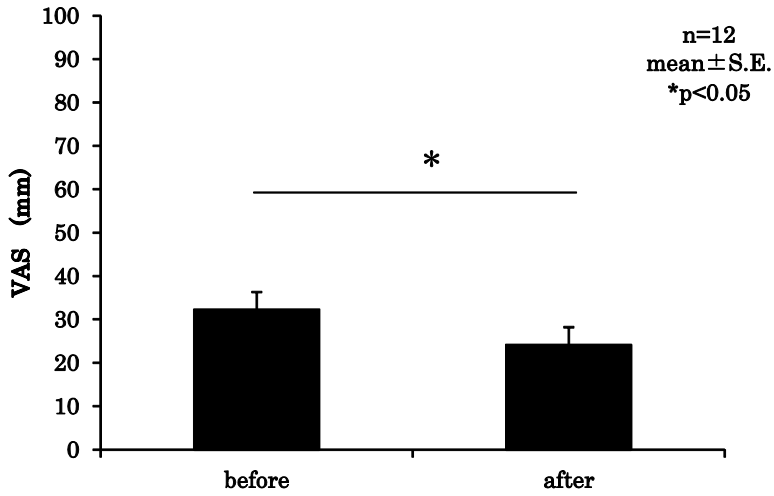

Fig.3 This figure shows the mean lower back pain VAS score of acupuncture stimulation before and after. After acupuncture stimulation, the mean VAS score was a significant decrease ($P < 0.05$).

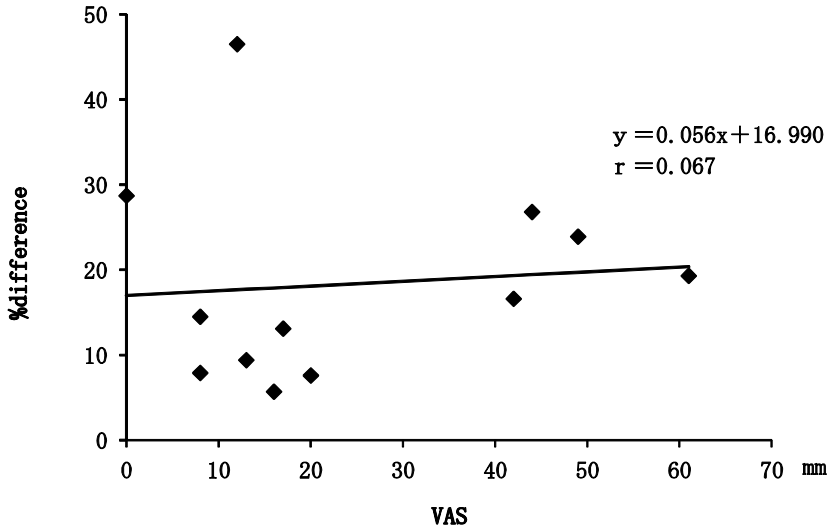

Fig.4 This figure shows the correlation between the VAS score and the% difference of acupuncture stimulation after. There was no significant difference.

erector spinae muscles with the left and right side of the muscle assisting each other. Previous studies have indicated that left–right asymmetry in the muscle activity of the lumbar erector spinae is a key factor in lower back pain, where over-tension of the muscle is suggested to be the cause[16]. In this study, EMG asymmetry was evaluated as % difference of the peak values of integrated EMG recordings from the left and right erector spinae muscles[14,15,17]. Donaldson et al. have reported that the % difference is ≥20% in subjects with lower back pain[14]. In the present study, the left–right difference at preintervention was ≥20%, excluding one subject (table1), at 31.1 ± 2.9% on average. Abnormal EMG activity associated with lower back pain was observed to be consistent with previous studies.

Our results revealed that the % difference significantly decreased after acupuncture stimulation. Improvement after acupuncture stimulation in healthy subjects with a difference of ≥20% between the right and left symmetry has been previously demonstrated[15]. In previous studies[15], Tanaka et al. stimulated the erector spinae only by insertion acupuncture, electro-acupuncture stimulation

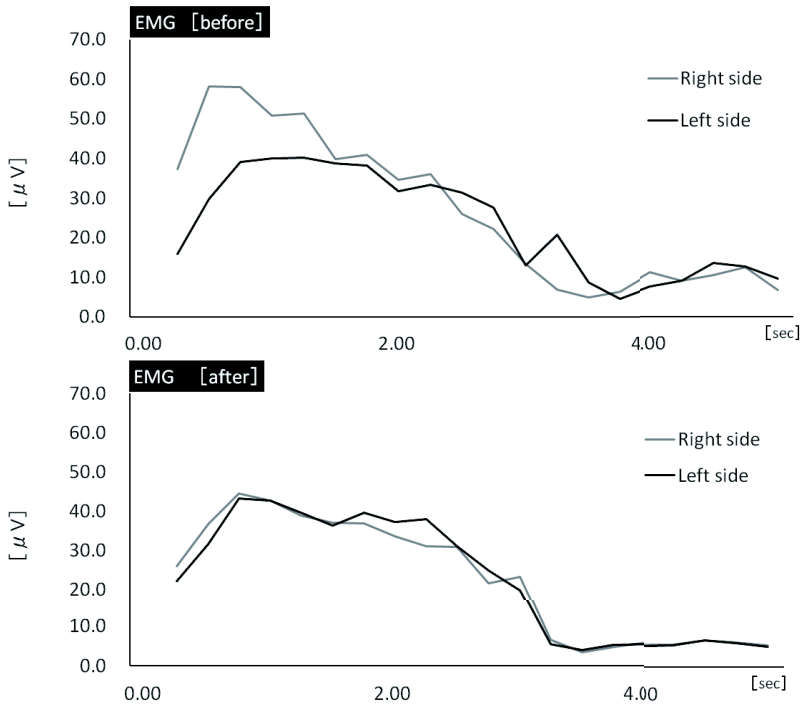

Fig.5 This figure is an example showing the EMG activity of the right and left lumbar erector spinae muscles of the trunk flexion. After acupuncture stimulation, %difference was decreased.

was not performed. Electric acupuncture stimulation can be expected that the intramuscular circulation is improved by the muscle to contract, muscle tension and pain are relieved[6]. In this study, we stimulated the erector spinae by electro-acupuncture and observed that acupuncture stimulation to the erector spinae led to improved asymmetrical trunk flexion. Although this study does not clearly demonstrate the mechanism for the decrease in EMG asymmetry after acupuncture, the lumbar spine in trunk flexion revealed that the left–right difference between erector spinae muscles was reduced suggesting that acupuncture stimulation is likely transmitted through a complex interaction of the central and peripheral systems[15].

The degree of pain was also significantly reduced after acupuncture. The effect of pain suppression by electro-acupuncture has been proven in previous studies. Acupuncture exerts several effects including an analgesic effect through endogenous opioid production[18], activation of the descending pain modulatory system[19], and diffuse noxious inhibitory control[20]. However, it is not possible to state whether these processes were involved in the present study.

Improvement in both the asymmetry of EMG activity of the erector spinae and the degree of back pain after acupuncture has been previously reported. However, the extent to which pain-suppression is associated with resolution of asymmetry of EMG activity of the erector muscle of the spine is not clear. Therefore, the present study investigated whether there is any relationship of the asymmetry of EMG activity and pain after acupuncture stimulation. However, there was no clear correlation. After acupuncture stimulation, VAS of 3 subjects who increased difference% did not increase. Regardless of whether they have lower back pain or not, it speculated that acupuncture stimulation to the erector spinae has the effect of improving the asymmetry of EMG activity of the trunk flexion. The asymmetry of the erector spinae-EMG activities is not modified by the pain factor complex. For example, in subjects with back pain, delays in the activity of the transversus abdominis during limb surgery have been reported[7]. Therefore, it can be inferred that factors other than the muscle activity of erector spinae contribute to lower back pain. Acupuncture may aid in the prevention of lower back pain by improving the asymmetry of the muscle activity in subjects with lower back pain, thereby improving the muscle coordination of subjects with lower back pain.

In this study, it was observed only effect immediately after acupuncture stimulation. It is not clear whether effects lasted how long for it. The difference in the pain level between the sides and pathogenesis of lower back pain were not taken into consideration. Moreover, until predicted changes were observed, acupuncture stimula-

tion was continued. Because there was no placebo or control group, to compare the effects of acupuncture on pain relief with other interventions was not possible. Therefore, in future, it is necessary to compare the demonstrated effect in other pathologies and against other therapeutic interventions. In addition, to further test the accuracy of this protocol, a study that includes a control group is essential to completely demonstrate the clinical significance of this protocol.

Ⅴ. Conclusion

We investigated whether there was a relationship between the asymmetry of EMG activity and pain after acupuncture stimulation. We found that the % difference in the left–right asymmetry and the degree of lower back pain decreased after acupuncture stimulation. However, the correlation between pain and the asymmetry of EMG activity of an erector muscle of spine after stimulation was not clear.

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