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Original Research

Electro-acupuncture significantly delayed multifidus muscle reaction time in athletes with lower back pain

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Abstract

[Objective] The aim of the present study was to investigate the effect of electro-acupuncture of the lumbar region on the reaction time of the trunk muscles during postural sway.

[Methods] This study is non-blind comparative study. The subjects comprised 7 young athletes with lower back pain in the lower back pain (LBP) group and 8 healthy athletes in the control (CON) group. We measured the muscle reaction time of the trunk when the floor below the right leg suddenly tilted during standing at rest. Three measurements were taken for the right multifidus muscle and the right internal oblique muscle and median values were used for analysis. 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 multifidus muscle reaction time was significantly delayed in the LBP group after electro-acupuncture stimulation compared with that before stimulation ($P<0.05$). In the CON group, no significant difference was observed between the times before and after electro-acupuncture stimulation. No significant differences were noted in the internal oblique muscle reaction times before and after electro-acupuncture stimulation in either the LBP or CON group.

[Conclusion] While no differences were noted in healthy individuals, electro-acupuncture significantly delayed multifidus muscle reaction time during postural sway in athletes with lower back pain.

Key words: *acupuncture, reaction time, EMG, multifidus muscle, lower back pain*

I. Introduction

The incidence of sports injuries is expected to increase as the number of people participating in sports increases. Previous studies have reported that the incidence of lower back pain is high among those with experience in competitive sports.[1)] Lower back pain follows a chronic course and can be a major obstacle to sports activities and competition.

Since the 1980s, the importance of the lumbar stability in alleviating and preventing lower back pain has been recognized. It has been known that deep trunk muscles stabilize the trunk by the activities prior to the movement of the limbs[4,5)]. Therefore, in the field of sports, functional training program for the transversus abdominis and multifidus to improve the performance has been attracting attention. Early studies on the role of the lumbar spine reported a distinctive activity of the trunk muscles using electromyography (EMG). The flexion–relaxation phenomenon, in which the activity of the back muscle disappears when the trunk is bent forward to the maximum, can be observed in healthy individuals but is not observed in those with chronic lower back pain[2)]. Moreover, the majority of individuals with chronic lower back pain exhibit asymmetrical muscle activity in the erector spinae muscles when bending forward as well as a delayed reaction time of the transverse abdominal muscle compared with healthy individuals, and this fea-

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ture is even present in those with only a history of lower back pain[3-5].

The first line of treatment for lower back pain is conservative therapy. One form of conservative therapy is acupuncture, which is shown to be effective in alleviation of pain, adjustment of muscle tonus, and recovery from dysfunctions after sports injuries[6-8]. Electro-acupuncture for athletes with lower back pain has been reported to be effective in improving training status[9]. Acupuncture is therefore expected to be useful in the expedited recovery of sports injuries secondary to pain relief as well as prevention of sports injuries secondary to muscle tone adjustment.

Acupuncture is known to improve muscle tonus; therefore, it may also affect the muscle reaction time. The muscle reaction time is the duration between the stimulus and the muscle stretch reflex, which is controlled by muscle tonus via γ motor neurons in a variable manner[10]. To the best of our knowledge, no study till date has investigated the effect of acupuncture of the lumbar region on the reaction time of the trunk muscles. If electro-acupuncture affects the muscle reaction time and adjusts muscle tonus, it would be useful in athlete conditioning.

The aim of the present study was to investigate the effect of electro-acupuncture of the lumbar region on the reaction time of the trunk muscles during postural sway in athletes with low back pain and healthy athletes.

Ⅱ. Materials and Methods

1. Subjects

The subjects comprised 7 young athletes with lower back pain in the lower back pain (LBP) group (age: 19.6 ± 1.3 years; height: 174 ± 5.2 cm; weight: 67.3 ± 6.0 kg) and 8 healthy athletes in the control (CON) group (age: 21.5 ± 1.5 years; height: 172.6 ± 6.9 cm; weight: 65.3 ± 7.1 kg).

All subjects were male university soccer players. In a prior interview, the subjects in the LBP group explained whether their lower back pain appeared during or after matches; however, this lower back pain was not enough to stop matches. In addition, the subjects were not diagnosed with lower back pain by a doctor (Table1).

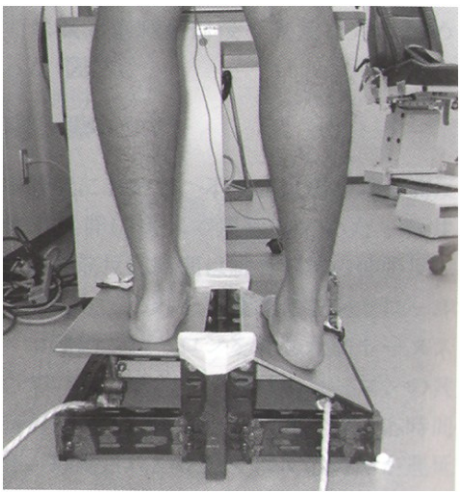

Fig.1 Trap door
A device that tilts by 25° very suddenly (“trap door”) was placed on the floor in the contact area of the right leg in order to induce postural sway. The subjects stood on the trap door floor, with equal force applied to both feet. The subjects also stood with their second toe and calcaneal protuberance positioned on a straight line marked on the floor. We measured the muscle reaction time of the trunk when the floor below the right leg suddenly tilted during standing at rest.

The purpose of the research was explained to the subjects who then gave their written consent to participate. This study was conducted with the approval of the Ethical Review Board of Tsukuba University of Technology.

2. Measurement devices and methods

A device that tilts by 25° very suddenly (“trap door”) was placed on the floor in the contact area of the right leg in order to induce postural sway (Fig. 1). The subjects stood on the trap door floor, with equal force applied to both feet. The subjects also stood with their second toe and calcaneal protuberance positioned on a straight line marked on the floor. We measured the muscle reaction time of the trunk when the floor below the right leg suddenly tilted during standing at rest. The trap

Table.1 Characteristic of low back pain subjects

Subject No.	Duration of illness(years)	Diagnosis	Pain region	Trigger	RDQ(pt)	VAS(mm)
1	4	none	both sides	during the competition	3	61
2	2	none	right side	during practice	1	44
3	7	none	both sides	in the ADL	1	17
4	4	none	left side	during the competition	1	30
5	0.5	none	right side	in the ADL	1	24
6	0.5	none	left side	unknown	1	45
7	0.7	none	both sides	after the return of the injury	1	50

This table shows Duration of illness, Diagnosis, Pain region, Trigger the onset, Roland-Morris Disability Questionnaire (RDQ) and lower back pain Visual Analog Scale (VAS) of low back pain subjects.

door was operated at random from behind the subjects so that they were unaware of the timing.

Surface electromyography (EMG; Biometrics Ltd., Newport, UK) was used to measure muscle activity. EMG waveforms derived from surface EMG were amplified by an amplifier and recorded in synchronization with the tilt timing of the trap door. Recorded EMG waveforms underwent A/D conversion at a sampling frequency of 1000 Hz and were input into a computer.

The TRAIS System (DHK, Tokyo, Japan) was used to analyze EMG waveforms. Motion artifacts were removed from EMG waveforms with a band-pass filter. The muscle reaction time was the time between the tilt of the trap door and the initiation of muscle activity as indicated by a spike in the EMG waveform when the rectified EMG waveform at rest reached its peak (Fig. 2).[11,12)]

Three measurements were taken for the right multifidus muscle and the right internal oblique muscle and median values were used for analysis. Placement of the electrodes was in accordance with previous studies[13,14)]. The right multifidus placement site was 2 cm right and lateral to the fifth lumbar spinous process, and the right internal oblique muscle placement site was 2 cm below and medial to the right anterior superior iliac spine (Fig. 3). Bipolar surface electrodes with an integrated electrode and amplifier were used. The distance between the electrodes was 10 mm. The electrodes were placed parallel to the muscle fiber direction of each muscle. The earth electrode was placed on the wrist of the right hand.

The electrode placement sites for the internal oblique muscle were consistent with the reaction time of the transverse abdominal muscles in a previous study[14)] that used surface EMG and wire EMG, which was reported to be highly reproducible. The present study demonstrates the reaction times of the internal oblique and transverse abdominal muscles.

3. Electro-acupuncture stimulation method

There were 4 acupuncture sites in the muscle layer corresponding to the multifidus muscle on the left and right straight sides of the spinous process (Jiaji; EX–B2) at the height of the bilateral fourth and fifth lumbar spinous processes. Disposable stainless steel acupuncture needles (Seirin Co., Ltd., Shizuoka, Japan; 60 mm in length, 0.2 mm in diameter) were inserted into the muscle to a depth of 3 cm. Electrodes were then attached to each of the acupuncture needles on the left and right sides and a current was applied at a frequency of 1 Hz using a low-frequency power supply unit (Zeniryoki, Fukuoka, Japan; Ohm Pulser LFP-4500A). Stimulation was performed for 10 min once twitch was confirmed. Acupuncturists of one was the acupuncture.

4. Statistical analysis

The reaction times of the multifidus and internal oblique muscles before and after electro-acupuncture stimulation were compared between the LBP and CON groups using the Mann–Whitney U test. Comparison of the reaction times before and after electro-acupuncture stimulation within the LBP and CON groups was performed using the Wilcoxon signed-rank test. SPSS Statistics ver.18 (IBM Corporation, Japan) was used for statistical processing and the significance level was set at <5%. Measured values are shown as mean ± standard deviation.

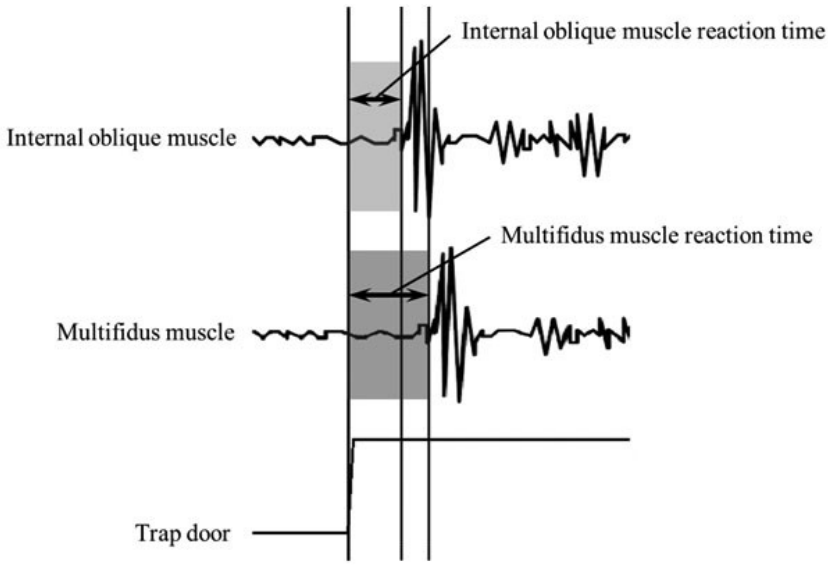

Fig.2 The muscle reaction time was the time between the tilt of the trap door and the initiation of muscle activity as indicated by a spike in the EMG waveform when the rectified EMG waveform at rest reached its peak.

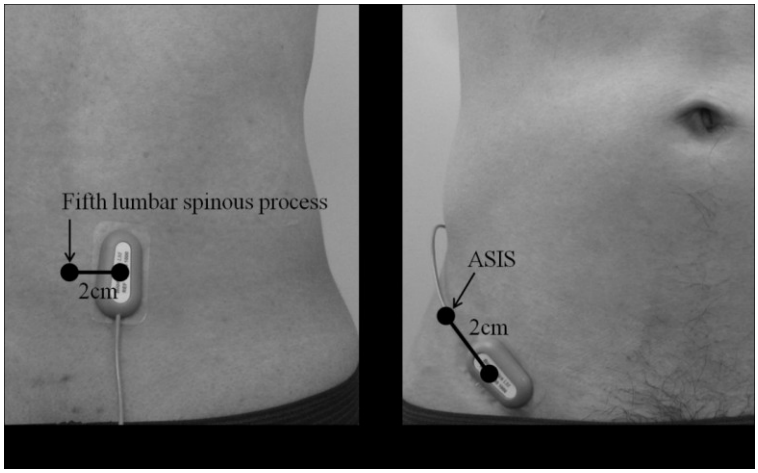

Fig.3 This figure shows the Placement of the electrodes. The right multifidus placement site was 2 cm right and lateral to the fifth lumbar spinous process, and the right internal oblique muscle placement site was 2 cm below and medial to the right anterior superior iliac spine(ASIS).

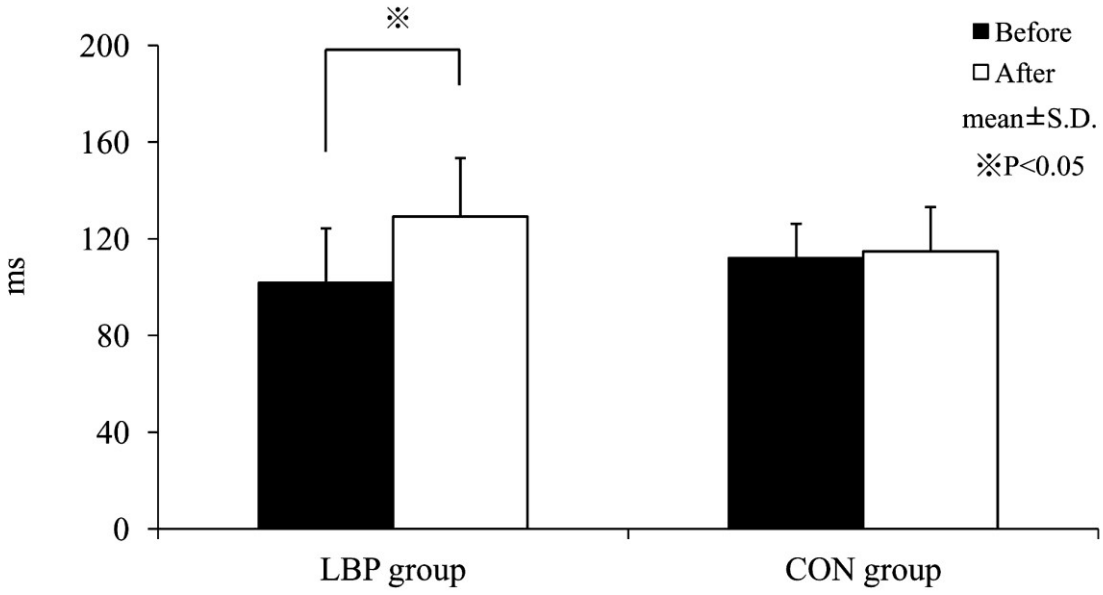

Fig.4 This figure shows the mean multifidus muscle reaction time of electro-acupuncture stimulation before and after. The mean multifidus muscle reaction time was significantly delayed in the LBP group after electro-acupuncture stimulation compared with that before stimulation (P<0.05).

Ⅲ. Results

1. Multifidus muscle reaction time

The muscle reaction time prior to electro-acupuncture stimulation was 101.2 ± 22.6 ms in the LBP group and 112.0 ± 24.2 ms in the CON group, indicating no significant difference. After stimulation, this time increased to 129.2 ± 14.2 ms in the LBP group and 114.8 ± 18.4 ms in the CON group, indicating no significant difference. The reaction time was significantly delayed in the LBP group after electro-acupuncture stimulation compared with that before stimulation (P=0.018). In the CON group, no significant difference was observed be-

tween the times before and after electro-acupuncture stimulation (Fig. 4).

2. Internal oblique muscle reaction time

The muscle reaction time prior to electro-acupuncture stimulation was 45.6 ± 24.3 ms in the LBP group and 67.5 ± 27.4 ms in the CON group, indicating no significant difference. After stimulation, this time increased to 59.1 ± 21.8 ms in the LBP group and 77.5 ± 23.1 ms in the CON group, indicating no significant difference. No significant differences were noted in the reaction times before and after electro-acupuncture stimulation in either the LBP or CON group (Fig. 5).

Ⅳ. Discussion

Our investigation of the effect of electro-acupuncture on the reaction times of the multifidus and internal oblique muscles during postural sway demonstrated that multifidus muscle reaction time was delayed following electro-acupuncture in participants with lower back pain (LBP). When the body's stability is unexpectedly threatened while playing sports, the nervous system reacts immediately to control the posture, causing complex interactions to occur. The stretch reflex is involved in this reaction, generating afferent impulses by stretching muscle spindles and causing contraction by exciting the α motor neurons in these muscles. This latency of activity is called the muscle reaction time and is calculated from the start of muscle activity when articular motion occurs immediately in response to stimuli such as light or sound[15].

In studies to date, the reaction time of the trunk muscles has been confirmed as delayed in chronic lower back pain patients compared with healthy individuals[5]. In the present study, we observed no difference between the groups with regard to the muscle reaction times prior to intervention. However, following electro-acupuncture, multifidus muscle reaction time was delayed in the LBP group.

Yoshida *et al*. investigated the effect of acupuncture stimulation on the muscle reaction time and reported that electro-acupuncture stimulation shortened the muscle reaction time[16]. However, while the electro-acupuncture method was similar, the study focused on participants with ankle instability[16]. Therefore, it remains unclear whether differences in muscle reaction time changes caused by electro-acupuncture stimulation depend on the acupuncture site and attributes of the muscle in question.

A study using microneurography reported that electro-acupuncture suppresses adrenergic sympathetic nerve activity through somatic–autonomic reflexes and thus decreases muscle tonus and improves muscle hemodynamics[17]. Ishii *et al*.[10] reported that reaction time speeds up when muscle tonus is enhanced by excitement of γ motor neurons and slows down when muscle tonus is suppressed. This suggests that in athletes with lower back pain, electro-acupuncture stimulation produces a delay in the muscle reaction time by suppressing α motor neuron excitement at the spinal cord level, which suppresses γ motor neuron excitement and decreases muscle tonus. In other words, electro-acupuncture to the multifidus muscle in athletes with lower back pain delayed multifidus muscle reaction time by relieving muscle tonus.

Deep muscles in the trunk, namely the transverse ab-

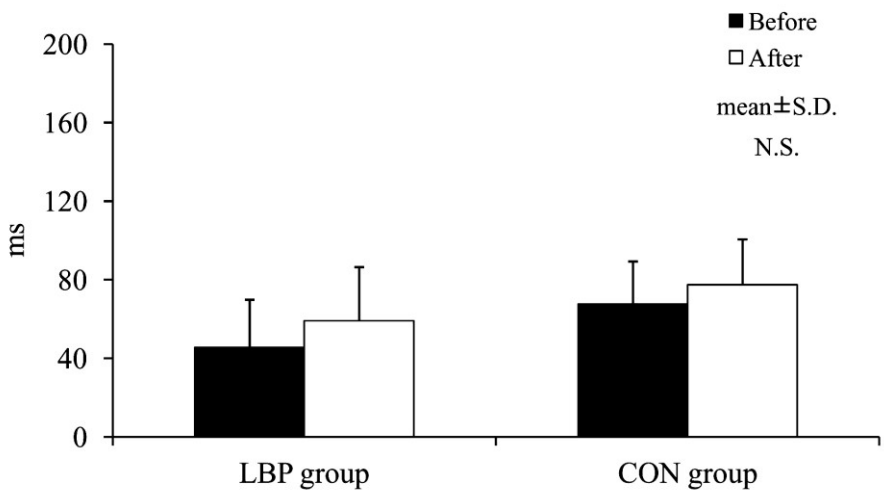

Fig.5 This figure shows the mean internal oblique muscle reaction time of electro-acupuncture stimulation before and after. No significant differences were noted in the internal oblique muscle reaction times before and after electro-acupuncture stimulation in either the LBP or CON group.

dominal and multifidus muscles, play an important role in achieving lumbar spine stability by interaction. Muscle reaction time of the transverse abdominal muscle is delayed with chronic low back pain patients. Therefore, the delay of muscle reaction time may be associated with instability of the lumbar spine. After electro-acupuncture stimulation, muscle reaction time of the multifidus muscles is delayed, but transverse abdominal muscle had no effect on muscle reaction time of the internal oblique muscle. Therefore, the delay of muscle reaction time of multifidus muscles by acupuncture stimulation cannot be clearly about the effects of the lumbar instability.

The present study found that electro-acupuncture delayed multifidus muscle reaction time, suggesting that this technique is useful in improving muscle tonus in those with lower back pain. However, the effect of delayed multifidus muscle reaction time on an athlete's performance has not been investigated. It is also unclear how long this delay is sustained. To examine the relationship between performance and muscle reaction time of the trunk muscles is necessary in order to demonstrate the effectiveness of electro-acupuncture for athletes. Furthermore, the present study did not examine motor neuron activity involved in muscle tonus. Therefore, further investigations are necessary to examine the mechanism of action underlying nervous activity caused by electro-acupuncture.

Ⅴ. Conclusion

The present study investigated the effects of electro-acupuncture on the reaction times of the multifidus and internal oblique muscles during postural sway. While no differences were noted in healthy individuals, electro-acupuncture significantly delayed multifidus muscle reaction time during postural sway in athletes with lower back pain.

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