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Original Article

Effect of exercise therapy combining electrical therapy and balance training on functional instability resulting from ankle sprain—focus on stability of jump landing

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Abstract. [Purpose] Functional instability leads to a delay in the muscle reaction time and weakness of the peroneal muscles. The present study examined the effects of transcutaneous electrical nerve stimulation during balance exercise on patients with functional instability of the ankles, including the ability to land after jumping at the center of foot pressure. [Subjects] The subjects were seven males with a history of ankle sprain. All had a sprained ankle score of ≤80 points on Karlson's functional instability test. [Methods] They were asked to jump over a 20-cm-high platform sideways for 10 consecutive seconds on a force plate with one leg. The length of the center of pressure was measured for comparison of balance exercise and balance exercise with simultaneous transcutaneous electrical nerve stimulation. [Results] The length of the center of foot pressure on the sprain side was significantly greater than on the non-sprain side under both conditions. Under the balance exercise with simultaneous transcutaneous electrical nerve stimulation therapy condition, the length of the center of foot pressure on the sprain side was significantly reduced, with the values being 627.0 ± 235.4 and 551.8 ± 171.1 mm before and after the challenge, respectively. [Conclusion] Ankle instability on the sprain side was significantly reduced under the balance exercise with simultaneous transcutaneous electrical nerve stimulation therapy condition before and after the challenge. Peroneal muscles showed increased activity caused by common peroneal innervation.
Key words: Ankle sprain, Jump-landing, Electrical therapy

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INTRODUCTION

Lateral ankle sprain (LAS) is one of the common injuries experienced in sport. Instability associated with LAS is classified into three types: structural, functional, and both structural and functional instability[1)]. Structural instability (SI) is a deviation from the normal physiological range of motion. In contrast, functional instability (FI) is instability of ankle joint sprain regardless of SI[2)].

It has been reported that ankle sprain caused by noncontact damage often occurs during jump landing and direction change[3)]. FI occurs at a rate of 10–30% after acute ankle sprain[4)]. Karlsson and Peterson reported that FI led to a delay in the muscle reaction time and weakness of the peroneal muscles[5)]. Furthermore, an increased resting motor threshold might indicate deficits in peroneus longus corticomotor excitability in people with chronic ankle instability (CAI)[6)].

In our previous study, we assessed whether electrical stimulation of the peripheral nerve for a specific period of time increases the excitability of the cerebral cortex[7)]. Increases in pinch force and grip strength were observed as a result of by electrical stimulation of the median nerve of healthy subjects[8)].

In the present study, we examined the effects of transcutaneous electrical nerve stimulation (TENS) during a balance exercise on patients with FI of a sprained ankle, including the ability to land after jumping at the center of foot pressure (COP).

SUBJECTS AND METHODS

The subjects were seven males (mean age, 20.3 ± 0.8) with a history of ankle joint sprain, and a sprained ankle score ≤80 points on Karlson's functional instability test[5)]. All subjects provided informed consent. We performed the anterior drawer and medial subtalar glide (MSG) tests for their sprained ankles. Patients who felt fear and/or pain were designated as positive. Patients with positive scores in either test were excluded from the study because of structural instability.

It should be noted that subjects were excluded if dorsiflexion was limited in the ankle to be studied. This study was

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Table1. Length of the COP on the force plate Unit: mm

	Sprain side		Non-sprain side	
	Before	After	Before	After
EX condition	585.6±158.9*	562.6±150.6	510.8±175.4*	505.8±187.2
TENS condition	627.0±235.4*,#	551.8±172.1#	539.3±160.0*	503.2±144.3

Before: before balance exercise or TENS therapy during balance exercise; After: after balance exercise or TENS therapy during balance exercise. Mean ± SD.
*p<0.05; #p<0.05

approved by the institutional research ethics committee of Kansai University of Health Sciences.

The subjects were asked to jump over a 20-cm-high platform sideways for 10 consecutive seconds on a force plate using one leg in a posture with the arms crossed in front of the chest. The length of the COP was measured for comparison of balance exercise (Ex condition) and balance exercise with simultaneous TENS therapy (TENS condition). The exercise was repeated three times for ten minutes, with a five-minute break, and included the front lunge, side lunge, stepping, squat, and one-leg standing. It should be noted that the length of the COP was normalized by dividing it by the jump-landing time. TENS therapy was maintained for 40 minutes for the common peroneal nerve. The stimulation conditions were as follows: 4.8 ± 1.5 mA, single-phase square wave, pulse width of 1 ms, burst frequency of 1 bp, and pulse frequency of 10 Hz for the common peroneal nerve. TENS was administered with an Intellect Mobile Stim (Chattanooga, DJO UK Ltd., Surrey, UK). An adhesive pad electrode (5 × 5 cm) was placed on the lower edge of the head of the fibula, and used as a stimulating electrode. Measurements were carried out at intervals of over a week. Statistical processing was performed to examine the length of the COP on the sprain side and non-sprain side under the EX and TENS conditions using the Mann-Whitney U-Test, and the date were compared before and after the study task using the Wilcoxon test. The significance level was set at less than 5%.

RESULTS

The length of the COP on the sprain side was significantly larger than on the non-sprain side under both the Ex condition and TENS condition. Under the Ex condition, the length of the COP on the sprain side showed no significant change, with the values being 585.6 ± 158.9 and 562.6 ± 150.6 mm before and after the task, respectively. Under the TENS condition, the length of COP on the sprain side was significantly reduced, with the values being 627.0 ± 235.4 and 551.8 ± 172.1 mm before and after the task, respectively (Table 1).

DISCUSSION

Our results showed that, in both the EX and TENS conditions, the length of the COP during jump landing was significantly longer on the sprained side than on the non-sprained side. Many authors reported that, in patients with functional instability following ankle sprain, there was altered ankle position sense, slower reaction time of the peroneal muscle group, and worsening of posture control function[9, 10]. It was also reported that single-limb postural sway was significantly greater in ankles with functional instability than in the contralateral stable joint[11–13]. It was further demonstrated that the muscular reaction times of the peroneal muscles in sprained ankles were significantly slower than those in contralateral stable ankles and healthy control ankles. Thus, extension of the length of the COP during jump landing on the sprained side may be due to delay the contraction response of peroneal muscles, a property of functional instability. The body sway under the TENS condition during one-leg standing on the sprain side decreased compared with that under the EX condition. Application of electrical stimulation to the common peroneal nerve had an impact on the dorsal motor area, and the primary motor cortex became more active. Furthermore, the peroneal muscles showed increased activity as a result of common peroneal innervation, which was induced based on the method reported by Wu et al[7]. In another report, pinch force improved as a result of transcutaneous electrical stimulation of stroke patients. The bilateral peroneus longus resting motor threshold was higher in participants with CAL than in those without CAI. An increased resting motor threshold might indicate deficits in peroneus longus corticomotor excitability in people with CAI. The resting motor threshold and self-reported function were moderately correlated, suggesting that deficits in corticomotor excitability might influence the function[6].

As a limitation of the present study, conclusions cannot be made regarding the mechanism of effect of TENS in this study, because stimulation of the sensory nerves excites the α motor nerve fibers and is transmitted to the spinal cord ventral root rather than the dorsal root[14] and there is a path that passes sensory stimulation to the top line in the motor cortex from the thalamus[15]. It is necessary to examine changes over time because the long-term effect of TENS has not been verified. Therefore, it is important to carry out physical therapy in consideration of the influence on the central nervous system even after ankle sprain.

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