Effects of Ankle Eversion Taping on Muscle Activity in Chronic Ankle Instability Adults during Sudden Inversion

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Abstract: - Ankle sprain is an injury in which the ligament of the ankle is stretched or torn when a strong external force is applied to the ankle joint. This study was conducted to investigate the effect of ankle eversion taping on muscle activity in chronic ankle instability adults during sudden inversion. The subjects of this study were forty subjects with ankle instability. The subjects performed sudden ankle inversion on the trapdoor with and without taping applied. The application of taping was conducted randomly. The subjects performed the trapdoor test three times using dominant feet with a 60 sec rest period between tests. This study assessed muscle activity during sudden ankle inversion three times. The results of the ankle eversion taping showed a significant difference of Tibialis Anterior, Peroneus Longus, Peroneus Brevis muscles activity than no taping ($p<.05$). But, ankle eversion taping showed no significant difference of Gastrocnemius muscle activity than no taping ($p>.05$). The application of taping can be used as a method of prevention and intervention of ankle injury.

Key-Words: - Ankle Eversion Taping, Chronic Ankle Instability, Ankle Sudden Inversion, Muscle Activity.

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1 Introduction

Ankle sprain is an injury in which a ligament of the ankle is stretched or torn when a strong external force is applied to the ankle joint, [1]. In particular, ankle sprains account for 85% of lateral ankle damage due to inversion. This is because the lateral side of the ankle is composed of relatively weaker structures and tissues than the medial side. Also, since the range of motion (ROM) of inversion is greater than that of the ankle joint, it is easily damaged in inversion motion, [2]. According to previous studies, the area where sport injuries frequently occur is the lower extremity, and among them, the ankle joint occupies the second highest frequency. This ankle sprain is a very common injury in sport activities, and it accounts for a high frequency of injuries not only in athletes but also in adults who participate in sport activities, [3].

Ankle sprain is the main cause of activity disorder, and symptoms such as pain, edema, muscle weakness, and instability appear, [4]. Anterior talofibular ligament (ATFL) and calcaneofibular ligament (CFL) injuries are common in most ankle sprains. Due to this damage, the stability between the talus and fibula and between the calcaneus and fibula deteriorates, leading to chronic ankle instability, [5]. Chronic ankle instability means that ligament relaxation is confirmed through physical tests such as talar tilt test and anterior drawer test. It also means complaining of subjective feelings such as repetitive ankle sprains and giving-way of ankle joints in active daily life, [6]. There are two major causes of chronic ankle instability. The first is ankle joint muscle weakness. In particular, it has been reported that the tibialis anterior and peroneus muscles, along with other muscles around the ankle joint, play a role in protecting the ankle sprain during sudden ankle inversion and plantar flexion, [7]. The second is a decrease in proprioceptor function. It has been reported that this delays the reaction time of the peroneus muscle during sudden ankle inversion, [8]. As a result, the decline in proprioceptor function makes it difficult to control posture and causes ankle instability. In other words, when the muscle strength and proprioceptor around the ankle joint are normal, the stability of the ankle joint can be obtained, and re-injury can be prevented, [9].

Taping, balance training, proprioceptor training, muscle strength training are applied

clinically to improve ankle joint stability and prevent ankle sprain. In particular, it has been reported that taping is effective in reducing the recurrence of ankle sprains and managing chronic ankle instability, [10]. In addition, compared to various training methods, it can be easily applied and has the advantage of bringing an immediate effect. Therefore, the application of taping can be recommended as a primary treatment for patients with chronic ankle instability. According to a previous study, it was reported that taping applied to the ankle joint improved the proprioceptor of the ankle and assisted the muscle to be effective in improving the balance function and range of motion (ROM) of patients with chronic ankle instability, [11].

Many studies have reported that such taping has a positive effect in terms of prevention or treatment of chronic ankle instability. However, there is a lack of studies investigating the effect of taping application on the ankle joint in the situation of the mechanical process and damage mechanism in which the ankle joint is actually sprained. Therefore, this study used the trap door used for kinematic analysis of ankle injury. In other words, in a state where a dynamic situation in which the ankle joint is sprained was artificially provided, the effect of taping application on ankle joint muscle activation was investigated. The purpose of this study is to find out how ankle eversion taping affects the ankle muscles in sudden inversion situations, and to secure grounds for prevention and intervention of ankle injury by taping.

2 Methods

2.1 Subjects

This study was conducted using a randomized controlled design. Forty subjects with ankle instability but no history of neurological or psychiatric disease were recruited. Inclusion criteria were as follows: no history of a neurologic or psychiatric disease, no significant visual or vestibular impairment, the ability to independently support body weight during the task, experience of ankle sprain at least once and of 'giving way' of the ankle joint, and a Cumberland ankle instability tool score of < 24. All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted under the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Daegu University (IRB 1040621-201511-HR-018-02).

2.2 Study Protocol

This study used kinesiology tape with elasticity. The patient is seated in a comfortable position on a table that is high enough to prevent the feet from touching the ground, while the therapist applies the tape on the damaged ankle stretched with a tension of 70 – 80%, [12]. Ankle Eversion Taping (AET) method was used for taping. Ankle eversion taping was applied while gliding the distal fibula. First, place the hand on the anterior and inferior distal fibula, and hold the distal leg with the opposite hand and fix it. The therapist then glides the distal fibula posterior and superior. With gliding applied, taping is applied to the lateral malleolus, and the taping is applied posterior and superior to the distal fibula (Fig. 1). The subject performed sudden ankle inversion on the trapdoor with and without taping applied. The application of taping was conducted randomly, and each measurement was performed three times depending on whether taping was applied or not. The subjects performed the trapdoor test three times using dominant feet with a 60 sec rest period between tests. Since the subjects could detect when the trap door would open, visual and auditory information was blocked.

Fig. 1: Ankle Eversion Taping

2.3 Measurement Tools and Measurement Methods

2.3.1 Trap Door

For examination, a trap door was employed to analyze the ankle injuries kinematically, [13]. The trap door was a foothold designed specifically to induce sudden ankle joint inversion, similar to a lateral ankle joint strain. Once a patient stood on

the trap door with bare feet, a rope connected to the vertical supports at both sides was pulled, and the trap door opened, thereby inducing sudden inversion of ankle joints. The trapdoor platform rotated in an inverted manner by 25° from the neutral standing position. No resistance was applied to restrict trap door movement other than hinge friction. The subjects performed the trapdoor test three times using dominant feet with a 60 sec rest period between tests (Fig. 2).


Fig. 2 : Trap door

2.3.2 Electromyography

Muscle activity was measured by surface electromyography (EMG) (MP35, Biopac, Goleta, CA, USA). Signals were recorded using Biopac student lab PRO 3.7.1 software (Biopac System, USA). EMG electrode locations were as follows: tibialis anterior (TA), peroneus longus (PL), peroneus brevis (PB), and lateral gastrocnemius (GAS). The electrodes were placed as described by the surface EMG for non-invasive assessment of muscles (SENIAM) protocol, [14]. A ground electrode was placed on the lateral malleolus. For statistical analysis, EMG signal data were sampled at 1,000 Hz, bandpass filtered between 30 and 500 Hz, and converted to digital signals using Biopac student lab PRO 3.7.1. A notch filter at 60 Hz was employed to clean the power line noises. Root mean square (RMS) values of EMG data were calculated and were measured during trapdoor landing in 3 sessions with a 60-second rest period between repetitions. Maximum EMG signals were acquired during maximum voluntary isometric contractions (MVIC) for 2 seconds. %MVIC values

2.4 Statistical Analyses

The Shapiro-Wilk test was performed to check for the normal distribution of each measurement item, and the results for all items satisfied normality. The data were presented as mean ± standard deviation (Mean ± SD), and the general characteristics of the subjects were presented as descriptive statistics. One-way repeated ANOVA was used for the group analysis. Mauchly's mauchly's sphericity test was satisfied ($p>0.05$), and univariate analysis and within-subject effect test were performed. The data collected for this study were statistically processed using SPSS 26.0 for Windows (IBM, New York, USA) and the statistical significance level P value of < 0.05.

3 Results

The demographic statistics of a single group are shown in Table 1. Forty subjects (gender: male 28, female 12; age: 23.27±1.94 years; height: 171.82±7.79cm; weight: 66.15±14.76kg). Ankle eversion taping showed a significant difference of Tibialis Anterior, Peroneus Longus, Peroneus Brevis muscle activity than no taping ($p<.05$). When also Ankle eversion taping was applied, muscle activity was improved compared to no taping. But, ankle eversion taping showed no significant difference of Gastrocnemius muscle activity than no taping ($p>.05$) (Table 2).

Table 1. General characteristics of subjects

	Group (N=40)
Gender (M/F)	28/12
Age (year)	23.27±1.94
Height (㎝)	171.82±7.79
Weight (㎏)	66.15±14.76
Weight (㎏)	21.21±3.41

Mean±SD: Mean±Standard Deviation
CAIT: Cumberland Ankle Instability Tool
$^{*}p<.05$

Table 2. Comparison of the ankle muscle activity between the taping and non-taping

MVIC%	AET[a] (Mean±SD)	NT[b] (Mean±SD)	*p*	post-hoc
Tibialis Anterior	38.95±18.75	27.14±12.78	.001*	a>b
Peroneus Longus	69.01±19.53	52.18±20.25	.000*	a>b
Peroneus Brevis	23.37±7.91	19.43±7.52	.013*	a>b
Gastrocnemius	63.23±23.86	57.93±22.03	.301	

Mean±SD: Mean±Standard Deviation
AET: Ankle eversion taping; NT: No taping
*$p<.05$

4 Discussion

This study was conducted to investigate the effect of ankle eversion taping on the muscle activity of the ankle muscle in adults with chronic ankle instability. As participation in sport activities increases, ankle sprains caused by ankle inversion are very common. In other words, the application of taping was intended to prevent ankle sprain and to present it as one of the appropriate intervention methods for chronic ankle instability. In addition, most of the previous studies simply applied taping, followed by functional evaluation and simple muscle activity evaluation. However, this study aimed to investigate the effect of taping application on ankle joint muscle activation in the state of artificially providing a dynamic situation in which the ankle joint is sprained.

As a result of this study, the muscle activity of the tibialis anterior was 27.14±12.78% in no taping and 38.95±18.75% when taping was applied, showing a significant difference. The muscle activity of the peroneus longus was 52.18±20.25% with no taping and 69.01±19.53% with taping, showing a significant difference. The muscle activity of peroneus brevis was 19.43±7.52% with no taping and 23.37±7.91% with taping, showing a significant difference. The tibialis anterior is the agonist of ankle dorsiflexion, and the peroneus muscle is the agonist of ankle eversion. That is, the application of taping in the ankle eversion direction applied in this study assisted ankle dorsiflexion and eversion. Therefore, it is considered that there was a significant increase in muscle activity when taping was applied.

In addition, according to a previous study, when taping was applied to patients with patellofemoral pain syndrome (PFPS), muscle activity of the vastus medialis and vastus lateralis muscles significantly increased, [15]. Also, when taping was applied to soccer players and ankle sudden inversion was performed, it was consistent with the results of a study that showed a significant increase in muscle activity of the peroneus longus muscle, [16]. According to previous studies, the application of taping serves as mechanical support and proprioceptive feedback, and it has been reported that it is effective in improving muscle function, [17]. In other words, it improves the elastic force of elastic muscle taping to assist muscle force, and when the muscle is stretched, the force increases as the feedback function of sensory receptors in the skin increases. In this study, when artificial sudden ankle inversion was performed, it is considered that higher muscle activity was measured compared to no taping because taping increased the auxiliary and proprioceptive feedback function of the muscle. Taping can be used as a way to maximize athletic performance. It improves the function of muscles and joints, and can be recommended as a method of prevention and intervention of injuries.

As a result of this study, the muscle activity of gastrocnemius was 57.93±22.03% in no taping and 63.26±23.86 when taping was applied, but there was no statistically significant difference. These results were not consistent with the results of a study showing that the gastrocnemius muscle had a positive effect on dynamic ankle stability, [18]. In other words, the gastrocnemius muscle affects stability as a two-joint muscle that affects the movement of the knee joint and ankle joint in a dynamic environment. However, it is considered that the gastrocnemius muscle did not play a role in ankle stability when ankle sudden inversion, not a dynamic environment, was applied in this study. Also, the gastrocnemius muscle is an ankle plantar flexion agonist. Since taping was applied in the direction of ankle eversion and dorsiflexion, it is considered that the presence or absence of taping did not affect gastrocnemius muscle activity. In addition, according to previous studies, it was reported that the activity of the quadriceps and

gluteus muscles was greater than that of the gastrocnemius muscle due to the limitation of ankle movement when taping was applied. In other words, it is considered that there was no difference in gastrocnemius muscle activity in this study as taping provided ankle movement restriction, [19].

The limitations of the study are as follows. In the first dynamic situation, ankle sudden inversion was induced and was not measured. In fact, ankle sprains often occur in dynamic situations. However, in this study, ankle sudden inversion was induced and measured in a static standing state. A study considering the dynamic situation is needed in the future. The measurement was limited to the muscles around the ankle joint. It has been reported that the knee and hip strategy is used more often than the ankle strategy when a sudden posture change occurs, [20]. It is necessary to measure muscles around the knee and hip in future studies. Third, the small number of subjects makes it difficult to generalize. As a single group study, further studies with a larger number of subjects are needed.

5 Conclusion

Taping intervention is used for the purpose of improving exercise performance and preventing sport injury. Due to the advantage of being easily applied without any special side effects, it is also used by the general public as an intervention method for acute or chronic musculoskeletal patients. In summary, the application of taping had a positive effect on the improvement of muscle activity around the ankle during sudden ankle inversion. Therefore, the application of taping can be used as a method of prevention and intervention of ankle injury.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

-JongSung Chang has organized and executed the experiments.

-SeungMin Nam was responsible for the Statistics.