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The Immediate Effects of Elastic Taping on Center of Pressure and Foot Pressure Distribution

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| Abstract |

Purpose: Ankle instability is a common issue in both daily activities and sports, often leading to recurrent injuries. Elastic taping is a non-pharmacological intervention used to improve ankle stability. This study aimed to investigate the immediate effects of elastic taping on ankle stability, center of pressure (COP) movement, and foot pressure distribution.

Methods: A single-group pre-posttest design was employed, with 30 participants included in the study. Plantar pressure and COP parameters were measured before and after the application of elastic taping. Taping was administered in three distinct patterns to enhance ankle stability.

Results: Immediate effects of elastic taping were evident in COP parameters. Following taping application, there was a significant decrease in COP total displacement, COP area, and COP velocity. However, no significant changes were observed in plantar pressure parameters.

Conclusion: The application of elastic taping in this study demonstrated immediate effects on ankle stability and COP parameters, indicating its potential as a viable intervention for improving balance. Further research with larger sample sizes and long-term follow-up is needed to elucidate the sustained effects of elastic taping on ankle stability.

Key Words: Elastic taping, ankle stability, proprioception

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Ⅰ. Introduction

Ankle injuries can occur during various activities in daily life, including sports, when the body suddenly moves in an unexpected direction or undergoes rapid deceleration or acceleration. They can especially result from excessive inversion or eversion movements of the ankle (Nigg & Bobbert, 1990). Balance refers to the ability to consistently maintain the center of the body within one's base of support. Achieving a high level of balance control requires an integrated process of perceiving the surrounding environment and processing various sensory inputs from external sources, including planning and executing movements, all working together seamlessly(Umphred, 1995). Individuals with chronic ankle instability typically exhibit characteristics such as reduced ankle muscle strength and proprioception compared to those with normal ankles. Additionally, they may experience decreased reaction times in the calf muscles, ultimately resulting in impaired balance abilities (Mattacola & Dwyer, 2002).

Furthermore, patients exhibiting chronic ankle instability often experience an increased range of medial-lateral sway during the gait cycle, making it challenging to maintain stable weight-bearing. This can lead to a decreased quality of life and health-related issues in daily activities (Arnold et al., 2009; Hamacher et al., 2016).

In the quest to address ankle instability, various intervention methods have been applied. Among them, pharmacological therapy, a pain management approach, is effective in pain suppression and reducing excessive muscle tension. However, it often presents limitations due to potential long-term side effects associated with prolonged medication use. Therefore, there is a demand for relatively low-risk, yet effective interventions for individuals with pain (Jeong & Lim, 2010).

One non-pharmacological approach to improve ankle instability is taping. Taping is primarily used to support and protect injured areas for the enhancement of bodily functions, thus serving as a means to increase biomechanical stability. It can be categorized into non-elastic taping and elastic taping (Lohrer et al., 1999; McCaw & Cerullo, 1999).

Non-elastic taping not only provides mechanical restraint around the unstable ankle but also induces a deceleration of movements that exacerbate instability. Additionally, it promotes centripetal input to the central nervous system and can elicit a psychological placebo effect due to the application of taping. Thus, non-elastic taping is commonly used in ankle injury prevention during rehabilitation. However, due to its material properties that restrict movement, non-elastic taping can impede smooth execution of activities requiring agility, such as running or jumping, during sports participation (Ambegaonkar et al., 2011).

Elastic taping is applied along the muscles responsible for generating joint movement. It aims to create space between the muscles and the skin, leading to increased blood and lymph circulation. Elastic taping can also assist in improving impaired muscle activity and enhance overall motor function. Therefore, it is considered one of the prominent non-pharmacological therapies commonly used for patients with ankle instability (Kim et al., 2004). In daily life, during functional movements or various sports activities, individuals are often exposed to excessive physical stress, increasing the risk of re-injury, especially in previously weakened tissues due to past injuries. Non-pharmacological therapies such as taping can help reduce the risk of ankle injuries and may promote improved muscle function (Kang et al., 2013).

While previous studies have demonstrated the effects of elastic taping on increasing ankle stability and improving balance, most of them involved interventions lasting 4 to 6 weeks or longer. There is a lack of research

analyzing immediate changes in balance ability when elastic taping is applied. Therefore, this study aims to investigate the immediate effects of applying elastic taping to the ankles of healthy individuals on plantar pressure and center of pressure (COP) displacement.

Ⅱ. Method

1. Participants

The participants selected for the study were adults aged 20 and older, both male and female, who met specific criteria. To minimize individual differences in body center of gravity changes, the criteria included a BMI of 21 or below and no musculoskeletal injuries in the past 6 months. All participants agreed to participate in the study after receiving a sufficient explanation about the study. This study was conducted after approval from ASC IRB (IRB 70365-202307-002-02).

2. Procedures

This study was designed as a single-group pre-post evaluation. All participants underwent a preliminary assessment, which included a 30-second evaluation of plantar pressure and center of pressure characteristics. Immediately following the preliminary assessment, elastic taping was applied to enhance ankle stability. The first taping involved applying the tape parallel to the forehead between both malleoli, extending up to 5 cm above the malleoli. The second taping was done with an “I-shape” tape starting just below the inner malleolus and ending where the talus bone finishes. The third taping started just above the outer malleolus, crossed diagonally across the front of the ankle joint, attached to the arch of the foot, wrapped around the foot, attached towards the outside, then crossed from the outside to the inside, and finally finished by wrapping 1-2 times around just above both malleoli. Following ankle stability taping, participants were reassessed using the same evaluation tools while maintaining a straight posture on the assessment platform.

3. Outcome Measures

In this study, we utilized the Wintrack system (Medicapteurs, France) to evaluate changes in center of pressure (COP) and plantar pressure resulting from ankle taping. This device is designed with a 120 cm long measuring plate equipped with 12,288 sensors capable of capturing 200 images per second (200*Hz*). The assessment of COP changes included parameters such as sway distance, sway area, anterior-posterior and medial-lateral sway speed. Additionally, plantar pressure data was

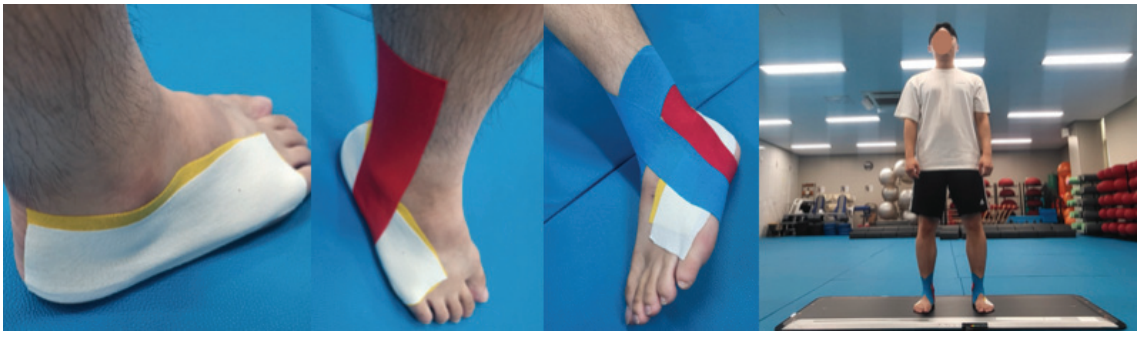

Fig. 1. Ankle taping and Evaluation of foot pressure and COP.

analyzed, incorporating variables like the pressure area under each foot and weight distribution ratio between the left and right feet. Among the indicators measured in this study, Area refers to the total support surface of both feet. Average P refers to the average pressure calculated across both feet. Trust refers to the driving force as the ratio of the total pressure of both feet.

4. Statistical analysis

The general characteristics of the participants in this study were described using means and standard deviations. The comparison of changes in center of pressure (COP) and plantar pressure before and after ankle taping was conducted using a paired t-test. A statistical significance level of less than 0.05 was set for the analysis.

Ⅲ. Result

1. General charateristics of participants

The total number of participants in this study was 30, and the general characteristics of the study participants are as follows. The average age of the participants in this study was 21.13 *years*, with 15 males and 15 females. The mean height was 169.17 *cm*, and the average weight was 61.23 *kg*. The mean BMI was 21.26, indicating a normal weight range, and all participants used their right foot as the dominant foot.

Table 1. General characteristics of participants (n=30)

	Mean	SD
Age (*years*)	21.13	2.17
Sex (*male/female*)	15	15
Height (*cm*)	169.17	7.55
Weight (*kg*)	61.23	9.28
BMI(*index*)	21.26	1.69

2. Changes of foot pressure distribution

The support area of the left foot decreased from 113.50 cm^2 before taping to 109.62 cm^2 after taping, but the difference was not significant. The support area of the right foot decreased from 115.40 cm^2 before taping to 112.67 cm^2 after taping, and the difference was not significant. The average pressure on the left foot decreased from 290.13 kg/cm^2 before taping to 278.27 kg/cm^2 after taping, and the difference was not significant. The average pressure on the right foot decreased from 284.33 before taping to 263.60 kg/cm^2 after taping, and the difference was not significant. The weight-bearing ratio for both the left and right feet did not show significant differences. The weight-bearing ratio for the left foot changed from

Table 2. Changes of foot pressure distribution (n=30)

	Pre-test	Post-test	Pre-post	*t*	*p*
Left area(cm^2)	113.50±14.66$^{\beta}$	109.62±25.99	-3.88±20.67	1.03	0.31*
Right area(cm^2)	115.40±14.14	112.67±24.24	-2.73±19.41	0.78	0.45*
Left average P(kg/cm^2)	290.13±53.72	278.27±27.69	-12.00±46.90	1.40	0.17*
Right average P(kg/cm^2)	284.33±63.73	263.60±50.49	-20.73±72.43	1.57	0.13*
Left trust(%)	50.00±2.69	49.76±3.15	-0.23±2.60	0.49	0.63
Righ trust(%)	50.00±2.69	50.23±3.14	+0.23±0.60	0.49	0.63

Left average P : Left average pressure, *Right average P: Right average pressure*
Mean±SD$^{\beta}$, $p<0.05$*

Table 3. Changes of COP perturbation (n=30)

	Pre-test	Post-test	Pre-post	*t*	*p*
Length of COP(*mm*)	145.23±56.43$^{\beta}$	112.96±44.03	-32.27±49.68	3.56	0.00*
Total area(mm^2)	155.48±123.13	80.97±74.70	-74.50±125.89	3.24	0.00*
Speed of F-B*(mm/s)*	3.09±1.21	2.52±1.02	-0.56±1.15	2.67	0.01*
Speed of L-L(*mm/s*)	2.98±1.33	2.30±0.99	-0.68±0.99	3.76	0.00*
Deviation of F-B(*mm*)	1.90±0.69	1.58±0.73	-0.32±0.99	1.78	0.09
Deviation of L-L(*mm*)	3.10±1.92	2.37±1.50	-0.73±1.47	2.75	0.01*

F-B : front to back COP, L-L: lateral to lateral COP
Mean±SD$^{\beta}$, $p<0.05$*

50.00 % before taping to 49.76 % after taping, and for the right foot, it changed from 50.00 % before taping to 50.23 % after taping.

3. Changes of COP pertubation

The total COP displacement decreased significantly from 145.23 *mm* before taping to 112.96 *mm* after taping. The total COP sway area decreased significantly from 155.48 *mm* before taping to 80.97 *mm* after taping. The COP's X speed decreased significantly from 3.09 *mm/s* before taping to 2.52 *mm/s* after taping. The COP's Y speed decreased significantly from 2.98 before taping to 2.30 *mm/s* after taping. The COP's X deviation decreased from 1.90 *mm/s* before taping to 1.58 *mm/s* after taping, but the difference was not significant. The COP's Y deviation decreased significantly from 3.10 *mm* before taping to 2.37 *mm* after taping.

Ⅳ. Discussion

Indeed, maintaining balance is crucial for various activities, including walking, and it involves the coordination of skeletal muscles and multiple joints in the upper and lower extremities. Especially for stable walking, the balance and stability of the feet, which are responsible for contact with the ground, are of paramount importance (Choi & No, 2011). When the range of motion in the ankle joint is reduced, it can lead to a decrease in foot stability. To compensate for this, the body may engage in compensatory movements in other areas to maintain balance. Specifically, limitations in ankle joint mobility may result in increased movement in the hip joint and trunk. Consequently, this increased movement can lead to a greater range of motion in the center of gravity, resulting in increased energy expenditure to maintain balance (Horak, 1987). In previous studies, changes in balance ability according to taping were conducted using a balance assessment tool. In this study, we attempted to understand the impact on balance ability based on changes in COP. In this study, we evaluated changes in the pattern of weight distribution and plantar pressure after applying elastic taping to ensure ankle stability. Since the feet and ankle joints provide stability and mobility necessary for weight-bearing and weight transfer, measuring plantar pressure can help observe various signs related to the feet in functional activities, including walking. Additionally, plantar pressure can determine and provide assistance in balance-related issues in various musculoskeletal and neurological conditions (Orlin & McPoil, 2000).

The left support area decreased from 113.50 cm^2 before taping to 109.62 cm^2 after taping, while the right support

area decreased from 115.40 cm^2 to 112.67 cm^2. However, there was no significant difference in either case. The average pressure distribution on the left foot decreased by 3.88 %, and on the right foot by 2.73 % compared to the pre-taping evaluation, but these changes were not statistically significant. The trust values, indicating the weight-bearing ratio between the left and right feet, increased by 0.23 % for both feet, with no significant difference observed.

Although there were numerical changes in all plantar pressure-related metrics, no statistically significant differences were observed. The size and distribution of plantar pressure can vary due to factors such as the structural and functional condition of the feet, pain, shoe wear, and the condition of the walking surface (Paik & Im, 1997).

In this study, the total COP displacement significantly increased by 32.26 *mm* compared to the pre-taping evaluation. The total COP displacement area decreased significantly from 155.48 mm^2 before taping to 80.97 mm^2 after taping. The increase in total COP displacement and the decrease in the displacement area indicate that during the measurement period, there was a reduction in the amount of movement in the participants' centers of pressure. This suggests that before applying ankle taping, the body's center of pressure was relatively stable and maintained.

Elastic taping has a positive impact on muscle function correction, blood circulation, pain reduction, realignment of subluxated joints, restoration of fascia and muscle function, and improvement in proprioception (Lee & Lee, 2015). Applying taping reduces the ankle joint range of motion that can lead to injuries during landing after a jump compared to barefoot conditions (Kim et al., 2009). For individuals with chronic ankle instability, ankle taping enhances proprioception, increases self-efficacy, boosts confidence in dynamic tasks, and reduces anxiety, encouraging continued physical activity or sports participation (Halim-Kertanegara et al., 2017).

The COP X speed decreased from 3.09 *mm/s* in the pre-taping evaluation to 2.52 *mm/* in the post-taping evaluation, but the difference was not statistically significant. However, the COP Y speed decreased from 2.98 mm^2 in the pre-taping evaluation to 2.30 mm^2 in the post-taping evaluation, and this difference was statistically significant. X speed represents the speed of movement generated when the body's center of mass moves forward or backward. A decrease in the speed of COP movement in the lateral (left-right) direction suggests that during maintaining balance in a standing position, the COP moved at a relatively slower speed due to body sway, indicating that taping treatment led to more stable changes in body sway. However, there was no significant difference in the forward and backward movement of COP speed, which can be attributed to the taping method applied to the participants.

In this study, taping was applied by passing both malleoli and using a spiral taping technique that crossed the medial side of the ankle diagonally to provide ankle stability. It is believed that such taping methods were insufficient to ensure stability in the anterior-posterior aspect of the ankle joint. If taping methods that can reinforce the anterior-posterior area of the ankle joint are applied in conjunction with the taping used in this study, it may be possible to expect significant changes in COP X speed as well.

The application of taping provides external support to joints, aiding in functional movement by enhancing joint stability through ligament reinforcement and movement restriction. It is known that such external support can be expected to enhance joint stability (Green et al., 2004). In the case of the taping applied in this study, which focused more on the lateral (left-right) direction of the ankle joint, it is believed that the significant difference

observed in COP Y speed can be attributed to this concentrated effect

COP X deviation decreased from 1.90 *mm* in the pre-test to 1.58 *mm* in the post-test, but no significant difference was observed. On the other hand, COP Y deviation decreased from 3.10 *mm* in the pre-test to 2.37 *mm* in the post-test, and a significant difference was observed. A decrease in COP Y deviation indicates a reduction in the variability of COP sway distance in the lateral(left-right) direction, suggesting an increase in ankle stability in the lateral direction. Muscular force exerted by the human body is generated through the transmission of electrical signals from the central nervous system's motor neurons, which are generated at the motor neuron pool (Kim et al., 2005). However, when excessive muscle tension occurs, surpassing the level required for posture control or the demanded level of exercise tasks, accurate and appropriate muscle activity may not be achieved, leading to functional impairment in balance control.

Taping can increase the intensity and frequency of stimulation to the muscles, thereby increasing muscle responsiveness, i.e., muscle contraction, and potentially leading to increased strength (Csapo & Alegre, 2015; Donec & Kriščiūnas, 2014). It is known to have an effect in enhancing reflex inhibition of the neuromuscular system, which can help prevent muscle damage due to excessive tension (Kottke & Lehmann, 1990) It has been reported in studies that taping can reduce the frequency of ankle strain occurring during activities such as descending stairs or weight-bearing situations, particularly in weight-bearing situations such as descending stairs or during weight-bearing activities (Lohrer et al., 1999). The taping method applied in this study involved strapping both sides of the ankle joint as well as applying a spiral taping on the inner side of the ankle. This taping approach can be considered effective in reducing the frequency of ankle strain or twisting. As a result, in the post-assessment, there was an induction of activity in the muscles around the ankle joint, and it is believed that there were changes in the control of muscles required for the stable regulation of body movements.

On the other hand, there was no significant difference in X deviation, which can be attributed to the characteristics of the ankle joint. In the pre-assessment, the value for front-back deviation was much lower at 1.90 *mm* compared to the pre-assessment value of 3.10 *mm* for lateral deviation. This is because of the structural characteristics of the ankle joint, where the support surface extends from the ankle bones to the toes, providing relatively less deviation in the front-back direction compared to the lateral direction. Even with the application of taping to provide stability to the ankle joint, the fundamental skeletal structure remains relatively stable, leading to no significant changes in this parameter.

The limitations of this study include the small sample size, making it challenging to generalize the results. Additionally, the study focused on immediate changes following taping application, making it difficult to assess the long-term effects and sustainability of the intervention. This study was conducted as a pilot study, and in future studies, we plan to more clearly verify the differences between groups by setting up a comparison group.

Ⅴ. Conclusion

In this study, we applied elastic taping to the ankle and examined the changes in plantar pressure and COP. Immediate changes in plantar pressure were not observed when elastic taping was applied. However, there were significant differences in COP variables, including COP displacement distance, COP total area, and COP speed. Therefore, ankle taping can be suggested as an intervention for improving balance ability.

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