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Research Article

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# Effects of Elastic Taping and Non-elastic Taping on Static Balance Control Ability, Dynamic Balance Control Ability, and Navicular bone Drop in Young Adults

Jong-Gun Lim · Hyun-Woo Lee · Dongyeop Lee, PT, PhD · Ji-Heon Hong, PT, PhD · Jae-Ho Yu, PT, PhD · Jin-Seop Kim, PT, PhD · Seong-Gil Kim, PT, PhD†

Department of Physical Therapy, College of Health Science, Sunmoon University

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**| Abstract |**

**PURPOSE:** This study examined the effects of the low dye taping technique on the static and dynamic balancing ability and navicular bone drop when the low dye taping technique was divided into elastic and non-elastic taping.
**METHODS:** The subjects of the study were 31 volunteers without musculoskeletal disorders. The length (L) and anterior (A), posteromedial, and posterolateral values of the arch in the NO (normal eyes open), NC (normal eyes closed), PO (pillow with eyes open), and PC (pillow with close eyes closed) states were evaluated when barefoot and when Kinesio tape and non-elastic tape were applied. The measurements were analyzed using repeated ANOVA and an independent t-test. Post hoc tests were performed using a Fisher's LSD.
**RESULTS:** A significant difference was found in the arch L and A values using a foot scanner ($p < .05$). In addition, there was a significant difference in dynamic balance in the three directions ($p < .05$), and no difference was found in the case of static balance. As a result, non-elastic tape application helps improve the dynamic balance ability and arch of the foot.
**CONCLUSION:** The non-elastic tape technique is helpful for the foot arch function, and there is no difference in the static balance ability between Kinesio tape and non-elastic tape. Nevertheless, non-elastic tape is more helpful for the dynamic balance ability than Kinesio taping.

**Key Words:** Dynamic stability, Foot pressure, Kinesio taping, Low-dye taping, Non-elastic tape, Static stability

## Ⅰ. Introduction

The foot, which is essential for balancing the body and supporting weight, includes the longitudinal arch and transverse arch. The longitudinal arch is designed to support the body weight [1]. A flat foot is a condition with low or no arch [2]. A reduction in the height of the longitudinal arch or flat foot is associated with many musculoskeletal disorders, such as Achilles Tendinopathy, plantar fasciitis, tibial tendon dysfunction, patellofemoral disorder, and low back pain [3]. The causes of the collapsed longitudinal

†Corresponding Author : Seong-Gil Kim
sungkil83@naver.com, https://orcid.org/0000-0002-2487-5122
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arches and flexible flat feet include weakening of the intrinsic muscles and being overweight. Adult acquired flatfoot deformity caused by these factors is a common disorder that generally affects elderly women or women in their middle ages, leading to foot pain, poor foot alignment, and loss of function [5]. In addition, there is some evidence suggesting that excessive flat feet may damage the standing balance of a young, healthy person [6].

Weight in the standing position is placed on the talocalcaneonavicular joint, which causes pressure on the area underneath the talus, and makes the longitudinal arch flat [4]. Flat feet cause hyperextension and weakening of ligaments and plantar fascia, leading to an inability to accept and distribute weight. Thus, excessive compensatory actions are caused by the extrinsic muscles, resulting in overuse syndrome and foot imbalance [1]. The causes of the collapsed longitudinal arches and flexible flat feet include the weakening of the intrinsic muscles and being overweight. Adult acquired flatfoot deformity caused by these factors is a common disorder that generally affects elderly or middle-aged women, leading to foot pain, poor foot alignment, and loss of function [5]. In addition, there is some evidence that excessive flat feet may damage the standing balance of a young, healthy person [6,7].

There are various clinical methods to determine if people have flat feet, but the navicular drop test (NDT) is the most widely used. In this test, if the weight of a subject puts the longitudinal arch down, it is to measure the height of the navicular bone, and the 10mm difference is regarded as being excessive [8].

Flat feet, causing the abnormal alignment of the feet and ankles, lead to changes in proprioceptive input of the feet and lower limb alignment, affecting gait and spinal disorders [9]. To correct gait and spinal disorders, various clinical interventions have been provided to fix flat feet, including surgical correction, muscle strengthening, stretching, wearing braces, manipulation, and taping. Among these, plantar fasciitis taping is applied to increase the height of the longitudinal arch of the foot and adjust the height of the navicular bone [10]. When applying plantar fasciitis taping and non-elastic taping to a flat foot, non-elastic taping is considered an effective intervention for treating flat foot patients [11].

The foot accounts for only 5% of the human body but provides stability for balancing through plantar sensation and absorbs shock [12]. A structural or functional deformity occurs if the medial longitudinal arch of the foot descends or is completely lost, and the shock absorption ability decreases, causing a loss of balancing sensation and a decline in stability while walking and running. This leads to gait disorders and a decline in endurance [13,14]. According to the study results, conservative intervention with foot orthoses using arch support, which is effective for leg alignment and pain control, improved foot abnormalities, leading to an improvement in walking to the normal level [15].

Kinesio taping is a physical therapy approach used to support and stabilize the muscles and joints without limiting the range of exercise (ROM). The elastic properties of Kinesio tape are similar to those of human skin. Kinesio taping causes a rebound after application, resulting in a pulling force that acts as a major stabilizer in the target area. Kinesio taping is used widely by athletes and physical therapists. Over the past decades, Kinesio taping has played a role in managing various musculoskeletal disorders, such as shoulder pain, knee pain, ankle injury, plantar fasciitis, and tennis elbow. It is also used for rehabilitation [23]. In addition, comfort and free movement after applying Kinesio taping are unique characteristics that players value. There are many beneficial effects depending on the applied technology of Kinesio taping. The application of Kinesio taping has been proposed to improve muscle contractility by supporting weakened muscles. Reduces inflammation and pain by increasing lymph and blood flow. Increases the joint range of motion by adjusting the misalignment of muscle fibers, fascia, and joints. Improving blood circulation and increasing the proprioceptivity using Kinesio taping were also proposed [24]. In this study, Kinesio taping used a method to improve the pulling force and proprioceptivity, acting as a stabilizer. C taping is a hard tape made of non-elastic fabric that has been used widely to limit the range of motion of the joint. Therefore, it effectively prevents and treats lower extremity injuries [25]. In general, current taping methods are often inconvenient. One study comparing different types of tape found that C taping was the least comfortable compared to barefoot and Kinesio taping [26]. On the other hand, C taping significantly reduces the maximum inversion when standing on a platform and leaning to the side and brings the foot into a more neutral ankle position during walking and jogging. A non-elastic material and multiple strips are applied, providing mechanical stability. The neuromuscular effects [27,28] and some mechanical effects lasting 15–45 minutes may work together [29].

A previous study reported immediate effects of ankle taping on static and dynamic balancing [16]. Another study examined the effects of elastic and non-elastic tape on the foot, in which non-elastic taping stabilized the midfoot in patients with chronic ankle instability, and elastic taping stabilized the back foot in the sagittal plane [17]. Lee et al. [11] examined the differences in the effect between elastic and non-elastic taping using a foot scanner. On the other hand, there are no reports on the differences in balance and foot pressure between elastic and non-elastic taping using the low dye taping technique. Therefore, this study examined the differences in the static and dynamic balance ability and foot pressure using intervention when the longitudinal arch of the foot was held using elastic and non-elastic taping as a low dye taping technique. The study was based on the assumption that conservative intervention can improve foot deformity and gait.

## Ⅱ. Methods

### 1. Participants

For the study, 31 subjects were selected among male and female students aged 18 to 28 years of S University in Asan city, using the G-power program 3.1.9.7 version. The purpose and method of the study were fully explained to all subjects before they participated in the study. After the pre-tests, signed consent for voluntary participation was obtained from 31 participants who had not visited a clinic or been treated for any problem related to a static stance or gait disorders. The inclusion criteria were as follows: those who had not undergone surgery within three months; those who had no orthopedic medical history; and those who had no problem with their overall health status. According to a previous study [18], the effect size for repeated ANOVA was assumed to be .26, with a significance level (α) of .05 and a power of 0.80. The number of subjects required for repeated ANOVA was calculated using G power 3.1.9.7. (Heine Heinrich University, Düsseldorf, German). Moreover, the result indicated that a minimum of 26 people were required. As a result, 31 subjects were recruited, considering a potential dropout rate of 20% during the experimental measurements [18]. Written informed consent was obtained from all participants. Table 1 lists the characteristics of the participants. This study was approved by the Institutional Review Board (IRB) of Sun Moon University. (SM-202104-040-2)

Table 1. General Characteristics of the Participants (N = 31)

| Participants Information | |
|---|---|
| Sex | Male (n = 19/61.3%)<br>Female (n = 12/38.7%) |
| Age (years) | 22.58 ± 1.82 |
| Height (cm) | 170.59 ± 9.53 |
| Weight (kg) | 66.71 ± 15.43 |
| Foot size (mm) | 257.58 ± 18.34 |
| Navicular height (cm) | .94 ± .26 |

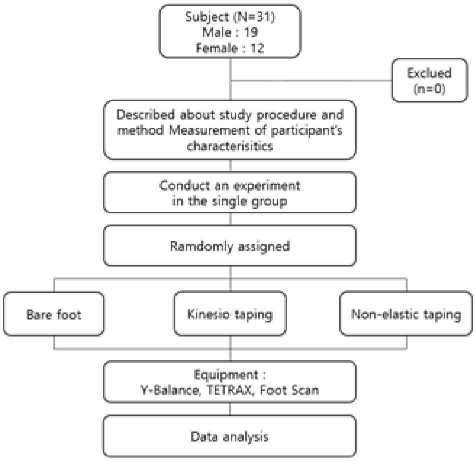


Fig. 1. Study design flowchart.

## 2. Design

A pre- and post-test comparison was conducted under three conditions: before taping, elastic taping, and non-elastic taping. The same researchers wearing the same pants applied a taping technique to provide equal circumstances to all participants and reduce interventional errors. Before function testing, the balance ability was assessed to prevent errors caused by muscle fatigue. Equipment for the experiments included a foot scanner, Y-balance kit, and TETRAX. They measured the foot pressure and the static and dynamic balance ability of the subjects.

## 3. Measurement Equipment

### 1) Foot scanner (foot pressure)

A device explains the pressure distribution under the foot with quick and detailed pictures presented as grayscale or color contour maps consecutively on a TV monitor. An explanation of the automatic analysis system, which can quantify the pressure and weight distribution under the foot while standing or walking using computer technology, was given [19]. The pressure distribution under the foot was compared for the differences in pressure changes with three measurements before and after elastic and non-elastic taping. The foot scan was performed using equipment from a Foot Analyzer (FA-48S, Tech storm Inc, Korea). For measuring the foot pressure, L (line drawn along the medial border of footprint) and A (smallest distance between the medial and lateral border of footprint) were measured while the subject maintained the standing posture.

### 2) Y-balance test

The dynamic stability was measured depending on the arrival distance during the Y-balance test (Perform Better, U.S.A.). To determine the differences in balance ability of subjects, they stood on one leg in the middle and pushed aside blocks toward the anterior, posterolateral, and posteromedial directions using the other leg. During the tests, all subjects were barefoot because they could be affected by shoes. They practiced twice for each direction and were then measured three times for each direction. For the measurement, they stood on one leg and put their hands on the pelvis, maintaining the stance in each direction. Maximum arrival distance was measured by reading a tape measure that was placed at the marginal part of an arrival indicator for the point where the farthest part of the foot reached. If they could not maintain the stance on the platform (e.g., if the stretching leg touched the floor or came off the platform for stance, or the stretching foot failed to contact the block), the test result of that time was discarded and retried. An equation of Step 1 was used to express the arrival distance as regularized figures as a percentage. In order to calculate the distance of YBT, the arrival distances for the anterior, posterolateral, and posteromedial directions were compared between the pre- and post-taping results of elastic and non-elastic taping.

### 3) TETRAX

The static balance ability was assessed using TETRAX (Tetra-ataxiometric posturography, Israel) on a stable


A : Longitudinal anchor strips to the the fifth metatrsal start in the bone attached to the head and along the lateral side of the head of the first metatarsal attached to the inside by pulling on the lateral.
B : The trans- verse arch support strips are attached to the bow by pulling from the outside along the plantar surface and attached to the anterior surface of the calcaneous to the heads of the metatarsalsr.

Fig. 2. Low-dye taping.

surface (NO) with their eyes open, stable surface (NC) with their eyes closed, unstable surface (PO) with their eyes open, and unstable surface (PC) with their eyes closed. Each condition was all measured for 32 seconds before and after the intervention. The stability index (ST) and weight distribution index (WDI) were used for the assessment. WDI was expressed as weight bearing in percent. Before the toes and heels of both feet touched the four force plates (A-B-C-D), the surface was made unstable using a pillow. The ST was measured for the changes in stance according to the changes in weight, which showed stability. The WDI is presented as the weight-bearing values with the percentage. All subjects were asked to stand in the same position, and the measurements were taken with their eyes open [22]. They were asked to maintain the stance for 32 seconds, staring at the marked point on the wall, which was 1 m ahead of them. The ST and WDI were calculated after the measurement and displayed on the screen of the connected computer. In this study, the comprehensive ST and WDI values were used, where lower values mean higher balance ability.

4) Low-dye taping

In the first stage, the ankle of a patient was placed in a neutral position, and the foot was kept at 90°. Starting from the medial side of the first metatarsal head and going along the medial border of the foot proximally around the back of the heel, a strap was attached to the lateral side of the fifth metatarsal head. In the second stage, a strap supporting the transverse arch was pulled from the lateral side along the plane to attach to the arch and the metatarsal head in the anterior region of the calcaneus. In the third stage, the last strap was applied in a similar manner to the first one to fix the whole taping structure. It was attached through the educational guidance of an experienced assistant (Fig. 2).

### 4. Statistical analyses

Descriptive statistics were used to analyze the average and standard deviation (SD) of each variable. For statistical analysis, SPSS/PC ver. 20.0 for windows program (SPSS INC, Chicago, IL) was used. A repeated ANOVA was used to analyze the differences before and after the intervention. An independent t test was used to examine the differences in the results between the groups. The statistical significance level was set to $\alpha = .05$, and a Fisher's LSD was used as a post hoc test.

## Ⅲ. Results

In terms of foot arches, a foot scanner revealed significant differences in the L and A values ($p < .05$) before the intervention and after using Kinesio taping and C taping ($p < .05$)(Table 3).

For the dynamic balance, the arrival distance in the anterior, posteromedial, and posterolateral directions were checked. After the intervention, significant differences were

Table 2. Comparison of the Normalized Dynamic Balance and Static Balance Data

| | | Intervention | | | | |
|---|---|---|---|---|---|---|
| | | Barefoot value | KT value | CT value | f | p |
| Dynamic balance (cm) | | | | | | |
| ANT | | .70 ± .01[c] | .71 ± .01[c] | .72 ± .01[ab] | 5.119 | .012* |
| PM | | 1.08 ± .02[c] | 1.10 ± .02[c] | 1.14 ± .02[ab] | 12.311 | .000*** |
| PL | | 1.07 ± .02[bc] | 1.13 ± .02[a] | 1.13 ± .01[a] | 17.376 | .000*** |
| Static balance | | | | | | |
| ST | NO | 14.77 ± .87 | 14.96 ± .78 | 15.81 ± .69 | 1.608 | .209 |
| | NC | 18.74 ± 1.19 | 20.04 ± 1.55 | 18.96 ± 1.06 | .969 | .385 |
| | PO | 17.80 ± 1.21 | 17.13 ± 1.08 | 17.21 ± .89 | .315 | .731 |
| | PC | 30.20 ± 2.70 | 27.49 ± 1.87 | 25.80 ± 1.59 | 2.829 | .075 |
| WDI | NO | 5.73 ± .56 | 5,84 ± .55 | 5.54 ± .56 | .338 | .716 |
| | NC | 5.08 ± .45 | 6.16 ± .52 | 5.61 ± .62 | 2.611 | .082 |
| | PO | 5.58 ± .54 | 5.45 ± .51 | 5.81 ± .62 | .409 | .666 |
| | PC | 6.92 ± 1.38 | 6.06 ± 1.19 | 6.87 ± 1.59 | 2.128 | .128 |

*p < .05, **p < .001, ***p < .001, mean ± standard deviation, KT: Kinesio taping (elastic taping), CT: C taping (non-elastic taping), ST: Stability Index, WDI: Weight Distribution Index, (ANT, Anterior), (PM, Posteromedial), (PL, Posterolateral), (NO, Normal eye open), (NC, Normal eye close), (PO, Pillow with eye open), (PC, Pillow with close eye), [a]Statistically different from Barefoot, [b]Statistically different from KT, [c]Statistically different from CT

Table 3. Standard Deviation (SD) of the Different Interventions During Static standing with a Barefoot State at Pre-taping, elastic Tape, and Non-elastic Tape

| | Barefoot | KT | CT | f | p |
|---|---|---|---|---|---|
| L (mm) | 11.44 ± .17[bc] | 10.97 ± .19[ac] | 10.47 ± .19[ab] | 39.346 | .000*** |
| A (mm) | 4.10 ± .16[c] | 3.98 ± .18[c] | 3.43 ± .15[ab] | 34.066 | .000*** |

ρ < .05, all values are mean ± standard deviation (SD). L (Line drawn along the medial border of footprint), A (smallest distance between the medial and lateral border of footprint), KT: Kinesio taping (elastic taping), CT: C taping (non-elastic taping), [a]Statistically different from Bare foot, [b]Statistically different from KT, [c]Statistically different from CT

found in arrival distance in all directions between the two groups ($p < .05$)(Table 2). There was no significant difference in ST and WDI in all stances of NO, NC, PO, and PC between before and after the intervention with Kinesio taping and C taping ($p > .05$)(Table 2).

## Ⅳ. Discussion

This study examined the arch length of the foot and static and dynamic balance control ability when elastic and non-elastic taping assisted the descending of the navicular bone in 31 normal young adults. A significant difference was observed between the arch length of the foot and the dynamic balance, and there was no significant difference in the static balance. A significant difference in dynamic balance ability was noted in the ANT, PM, and PL directions, and there was a significant difference in L and A lengths in the arch length of the foot.

C taping appeared to have a relatively limited effect on hind foot movement in inversion and abduction, clearly showing stabilizing effects on the subtalar structure and subtalar joint, and appeared to provide more restrictive conditions for the midfoot [30]. In this study, the effects of C taping were checked on the dynamic balance ability, such as walking and jogging, the ability to bring the foot to a more neutral ankle position, and the static balance ability through the stability brought by the application of non-elastic materials.

Low-dye taping is characterized by fixing the axis of rotation of the subtalar joint by wrapping the heel with tape, then controlling the flatness of the arch and relaxing the plantar fascia by joining the foot segments [31]. Low-dye taping is a useful technique for preventing foot injuries [32]. Low-dye taping can also increase the thickness of the heel pad, so it can provide a cushioning effect to the heel [33]. On the other hand, using non-elastic tape limits the mobility of the foot joints, leading to poor motor performance and changes in vertical stiffness caused by passive stiffness of the metatarsal bones [32]. Therefore, in this study, the effects of the dynamic and static balance when barefoot and elastic/non-elastic taping were examined, and the effects of taping on the arch of the foot were investigated. Kim et al. reported that changes in the plantar arch structure affect balance and gait abilities [33]. The significant improvement in dynamic balancing ability in the group with the arch support was attributed to the support on the medial longitudinal arch reducing the maximum load response and improving the leg stability, resulting in dynamic biomechanical effects [31]. This appeared to explain the improvement in dynamic balance ability when C taping was performed.

In this study, when the arch of the foot and dynamic and static balance BF, and after Kinesio taping and C taping were compared, both Kinesio taping and C taping did not affect the static balance ability. On the other hand, it had a significant effect on the dynamic balance ability and a significant effect on the arch length of the foot. A previous study reported an immediate effect of ankle taping on dynamic balance through the previous paper [16]. Moreover, non-elastic taping stabilized the midfoot well because of the effects of elastic and non-elastic tape on the foot [17]. Similarly, in this study, there were significant differences in the ANT direction, the PM direction, and the PL direction in the Y-balance test that confirmed the dynamic balance ability. Therefore, in the group to which the arch support insole was applied, the support for the medial longitudinal arch reduced the maximum load response and improved the leg stability, resulting in a dynamic biomechanical effect [31]. Hence, the significant improvement of the dynamic balance ability was explained. In addition, by attaching tape to the foot, the tape is stretched momentarily, and the elasticity of the tape quickly returns to the neutral position of the foot to increase joint stability. The foot scanner showed that Kinesio taping and C taping affected the L and A values in the arch length of the foot. A study was performed on the difference in the plantar pressure using a Foot scanner on the effect of elastic non-elastic taping through the low dye taping technique [11]. The effect on the length of A was the same, but in the present study, the taping intervention in the length of L was different from Kinesio taping and BF. Lange et al. (2004) reported a mean pressure reduction through low dye taping in the medial and lateral hindfoot, medial, central, and lateral forefoot regions. Moreover, the maximum pressure decreased in the medial and lateral hindfoot, medial forefoot, and central forefoot [34]. Therefore, it is believed that the value may be different when measured on a non-flat-footed person.

C taping was more effective than Kinesio taping and BF in the arch and dynamic balance tests of the foot, but the results were insignificant even when taping was used for posture maintenance functions, such as static balance. Based on these results, it is essential to use Kinesio taping and C taping correctly, considering the advantages and disadvantages of each intervention. Taping has little or no effect on the method of attachment, the correct attachment site, and inadequate tension. Both Kinesio taping and C taping are disposable, and the adhesive may come in direct contact with the skin, causing skin problems, but it is inexpensive and can be attached to any desired area. Although Kinesio taping has good elasticity and can be attached to various areas, C taping has no elasticity but has the advantage of limiting the range of motion of the joint.

This study examined the effect of elastic and non-elastic taping on the length of arch L and A of the foot and static and dynamic balance when the talus bone drop is supported, and the results were as follows. First, it was possible to confirm a significant difference when C taping was applied to the L (line drawn along the medial border of footprint) value and the A (smallest distance between the medial and lateral border of footprint) value for looking at the length of the foot arch. Second, the dynamic balance confirmed the difference between BF and Kinesio taping when C taping was applied in the anterior and posterior directions, and the difference between BF and BF when C taping and Kinesio taping were applied in the posterolateral direction. Third, regarding the static balance, no significant difference was found when comparing the NO, NC, PO, and PC postures for both ST and WDI before taping and after C taping and Kinesio taping. As a result, when the C taping technique is applied, it is helpful for the foot arch function, but there is no difference in static balance ability between Kinesio taping and C taping. Nevertheless, C taping is more helpful in dynamic balance ability than Kinesio taping.

This study has several limitations. First, because it was performed without exercise for a short period, further studies will be needed for a more extended period and additional exercise. Second, because the size of each subject's foot was considered, it was impossible to do the same taping between subjects, but the tape was applied with the maximum possible tension to homogenize this situation. Third, the subject's weight was considered a factor that could affect the magnitude and duration of the effect of the low-dye taping, but the participant's weight and the possible effect it could have on the effect of the low-dye taping were not considered. Fourth, the gait function test and dynamic function test were not performed. Fifth, the experiment was conducted on the general public, not on subjects with ankle disabilities. In addition, the study could not erase the learning effect, which may have affected the results.

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