J Int Acad Phys Ther Res 2020; 11(2): 2077~2089
ISSN 2092-8475

www.iaptr.org
https://doi.org/10.20540/JIAPTR.2020.11.2.2077

Effect of Ankle Taping Type and Jump Height on Balance during Jump Landing in Chronic Ankle Instability

Background: Chronic ankle instability is a common injury that decreases balance and negatively affects functional movements, such as jumping and landing.
Objectives: To analyze the effect of taping types and jump heights on balance with eyes open and closed during jump landings in chronic ankle instability.
Design: Within-subject design.
Methods: The study involved 22 patients with chronic ankle instability. They performed both double-leg and single-leg drop jump landings using three conditions (elastic taping, non-elastic taping, and barefoot) on three different jump platforms (30, 38, and 46 cm). Balance was measured using the Romberg's test with eyes open and closed.
Results: Interaction effect was not statistically significant. Balance with eyes open and closed was significantly improved in both the elastic taping and non-elastic taping conditions compared to the barefoot condition. There was no significant difference according to the jump height.
Conclusion: Individuals with chronic ankle instability demonstrated increased balance ability with eyes open and closed when jump landing. Elastic taping and non-elastic taping on the ankle joint can positively affect balance during landing in individuals with chronic ankle instability.

Keywords: *Chronic ankle instability; Elastic taping; Non-elastic taping; Jump height; Landing; Balance*

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Received : 07 April 2020
Revised : 18 May 2020
Accepted : 22 May 2020

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INTRODUCTION

Chronic ankle instability (CAI) includes residual symptoms, such as recurrent sprains, giving way, pain, edema, and reduced function of the ankle joint.[1] Causes of CAI include pathologic joint looseness, sensorimotor defects, or a combination of these.[2,3] CAI differs in gait pattern and static and dynamic balance other than those related to proprioception.[4-7] In the sensory motor system, the consequences of chronic injury reduce the tactile sensation of the soles. The reduced tactile sensations associated with the disease may cause gait instability and balance problems and may worsen with severity.[8]

Ankle joint taping helps muscle activation or muscle deficiency by preventing ankle sprains and improving proprioception and neuromuscular control.[9] Elastic taping is a useful clinical tool for correcting out-of-movement without limiting natural movement in sports because it can generate a pulling force in the direction in which the taping stretches.[10] Non-elastic taping provides mechanical stability because of applying multiple stirrups of non-elastic material.[11,12] Moreover, it provides deceleration of ankle sprain motion and other preventive benefits including afferent input to central nervous system and placebo effect.[11] Elastic taping and non-elastic taping has been found to have a positive effect on sports events, such as the one-foot hurdles test for basketball players with CAI.[13]

Jump height is one of the external factors of determining the landing type. Impact absorption mechanism after landing according to the jump height is different by relying on knee joint and ankle joint before and after fatigue.[14] Failure to effectively use the lower limb joints to perform the landing strategy can negatively affect instability.[15] When landing, more situations involve the single-leg than double-leg landing, and this one-foot landing has a higher risk of injury to the lower extremity joints than the two-foot landing.[16] Landing movements are common in daily activities and sports situations, and those with CAI who are physically active frequently perform various mechanisms of ankle sprains, such as change of direction and jump landing.[17] Modified proximal joint movement patterns, such as jump movements, provide insight into why individuals with CAI experience functional impairments due to increased giving-way and instability.[18]

Balance, is controlled by the nervous system, musculoskeletal system, proprioceptor, vestibular system, and visual system, allows the body to maintain a normal posture.[19,20] Balance requires the nervous system to respond to stimuli and mobilize muscle tissue properly, but muscle tissue itself must be able to carry out such commands.[21]

In CAI, dynamic stability is reduced on the frontal plane during a landing movement.[22] In functional ankle instability (FAI), recovering balance between a forward and backward sway and an internal and external sway when landing after a one-foot jump takes longer.[23] When the kinetic chain variability (e.g., jump movements) is too large to adjust and perform movement goals, the balance ability in CAI that develops effective solutions for adapting to specific sports-related challenges and demands on environmental constraints is impaired.[15,24]

Although many studies have been conducted on CAI, including on the control of CAI in single-movement strengthening exercises and balance-improvement exercises as well as on single-height jump and the related variables, insufficient studies have investigated balance according to the segmented jump heights related to functional movement by applying different taping types for CAI. In this study, we applied elastic taping and non-elastic taping to the ankle joint in young adults with CAI to analyze the effect on the balance with eyes open and closed of adults with CAI when landing after jump according to three jump heights.

SUBJECTS AND METHODS

Subjects

The subjects of this study included 22 adults with CAI who were in their 20s. All participants had scores of less than 24 on the Cumberland Ankle Instability Tool (CAIT) and were selected based on standard inclusion criteria that were approved by the International Ankle Consortium for patients with heterogeneous conditions of CAI in a controlled study.[25] They had no problems understanding the explanation of the experiment and performing the experimental process, and all voluntarily agreed to participate in the experiment. This study was approved by the Institutional Review Board of Namseoul University (NSUIRB-201811-002).

CAIT is the CAI measurement tool consisting of 9 questions related to instability symptoms for functional activities, including walking, stepping down, running, and jumping. Scores range from 0 to 30. If an individual scores 28 points or more, there is no instability, and if the score is 27 or less, the individual is classified as FAI. The lower the score, the more instability tends to increase.[26,27]

Subjects were excluded from this study who had musculoskeletal or neurological disorders, took medication that may affect the experiment, underwent intensive training to strengthen the lower extremities in the last 6 months, had a history of surgery of the lower extremity,[25] had skin disease, or had visual problem.

Experimental Procedures

After measurement of the physical characteristics for all subjects, single-leg jump and double-leg jump movements were performed at three heights of 30, 38, and 46 cm under three conditions of barefoot, elastic taping, and non-elastic taping. A body composition analyzer (InBody720, Biospace Co., Ltd., Seoul, Republic of Korea) was used to determine the general characteristics of the subjects. The order of taping types and jump heights were randomly applied to avoid order effects. They performed all measurements on one day. Based on previous studies that determined 30 cm to be the optimum combination of the jump height and the minimum contact time[28] and that 40 cm is higher in the tension of the Achilles tendon than other jump heights when landing after a jump,[29] platforms of heights of 30, 38, and 46 cm were used in consideration of the characteristics of the subjects.[30]

The subjects performed single-leg and double-leg jumps toward the front of the platform, with both hands placed on the iliac crest.[12,31] They performed single-leg jumps and landings when balance was measured with eyes open and performed double-leg jumps and single-leg landings when balance was measured with eyes closed because they had fear of falling. When landing after the double-leg jump, they performed the jump movement in a standing position with both lower extremities at a distance of the shoulder width. When landing after the double-leg jump, they performed the jump movement in a one-leg standing position on the ankle with CAI, and this position was kept for at least 2 seconds when landing.[12]

Each trial was performed 3 times, with a rest time of 30 seconds between each jump to prevent fatigue effects[32] and a rest time of 5 minutes between each condition.[15] The mean value was used in the statistical analysis in this study.

Interventions

For the elastic taping condition, an elastic tape (3NS TAPE, TS, Gimpo, Republic of Korea) was used in this study. To produce tension in the direction of eversion from the hind foot, two tapes were applied from the inner ankle to the outer surface of the calf (Figure 1). Tension was applied at 75%, and this tension is suggested to provide sensory stimulation and mechanical help to promote movement. The ankle joint was placed in a neutral position during the application of the elastic tape.[33]

For non-elastic taping condition, an non-elastic tape (Bartlett win taping C-TYPE, Nichiban Co., Ltd, Tokyo, Japan) was used in this study. The closed basket weave applied for non-elastic taping was composed of an 8-character shape with inner and outer stirrups to continuously control the back movement of the foot in the frontal plane by heel locking.[33] First, proximal anchors were placed by surrounding the distal lower leg 5-10 cm proximal to the malleolus, and distal anchors were placed proximal to the first metatarsophalangeal joint. Subsequently, with the ankle in a neutral position (0 degrees of the ankle joint), heel locks were applied via two stirrups starting from the medial with tensioning in the eversion and an 8-character shape with horizontal fixation slings on the proximal part of the insertion of the

Figure 1. Non-elastic taping

Figure 2. Elastic taping

Achilles tendon by crossing the anterior side after every stirrup (Figure 2).[12] Unlike elastic taping, non-elastic taping has no elasticity and is applied to all components at its length. During the application of the non-elastic tape, the ankle was placed in a neutral position.[33]

Outcome Measures

In this study, the Romberg's test with eyes open and closed was used to determine the subjects' balance ability. They stood on a jump platform of three heights under three conditions and performed a landing movement after jumping with the ankle with CAI. A balance assessment and training platform (BT4, HUR Labs Oy., Tampere, Finland) was used to measure the subjects' balance ability.

During each trial, the measurement posture was a one-leg standing position, which involved standing as stable as possible on the extremity with CAI with the other extremity at 30 degrees of the knee joint flexion along the frontal-posterior axis and with both hands placed on the iliac crest.[34] Auditory instructions were provided by a countdown from 4 seconds to 1 second before the start of the measurement and by the word "stop" after the measurement. During each trial, the measurements were performed in a quiet environment.[35] For the balance measurement with eyes open, participants were allowed to look at a point on the monitor about 65 cm away from the eyes[36] for 30 seconds while standing on bare feet.[37] When the balance was measured, the sensor on the platform (61 × 61 × 6 cm, 11 kg) found the subject's center of pressure and analyzed the posture fluctuation over time using the software. The variables measured in this study were trace length, C90 area, standard deviation velocity (STD velocity), velocity, STD X deviation, and STD Y deviation. The trace length is considered to be the sum of the lengths of all straight segments that connect the points in a time interval from one-fifth second to one-second successive points. The C90 area is minor ellipse area including 90% of center of pressure. The STD velocity is calculated by the square root of the sum of squares of deviations for X and Y coordinates divided by the sample size minus one. The velocity, sway average velocity, is calculated by dividing the total track length by the duration of the test is shared. The STD X and STD Y deviation is calculated by deviation of the average velocity for X and Y coordinates (User manual. HUR Labs Balance Software Suite. 2010.12.1.).

Data and Statistical Analyses

The data measured in this study were analyzed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test was used to demonstrate the normal distribution, and Levene's F-test was used to verify the homogeneity of the subjects. Two-way analysis of variance was used to compare the difference in balance according to the conditions (barefoot, elastic taping, and non-elastic taping) and the jump heights (30, 38, and 46 cm). When there was a significant difference in interaction or main effect, the Scheffé test was used for post-hoc analysis. The statistical significance level was set at α=.05.

RESULTS

General characteristics of the subjects

The general characteristics of the subjects are presented in Table 1.

Table 1. General characteristics of the subjects (n=22)

	Mean ± SD
Age (years)	21.33 ± 2.72
Height (cm)	166.56 ± 10.80
Weight (kg)	65.93 ± 18.97
BMI (kg/m2)	23.43 ± 4.91
CAIT (scores)	19.45 ± 4.41
Sex (Men/Women)	9/13
Unilateral ankle with CAI (Left/Right)	8/14

SD: Standard deviation, BMI: Body mass index
CAIT: Cumberland ankle instability tool, CAI: Chronic ankle instability

Results of changes in balance according to taping type and jump height

The analysis of the changes in balance according to the taping type and jump height found no significant differences in the interaction effect. A comparison of the changes in balance according to the taping type found no significant differences in trace length, C90 area, STD velocity, velocity, STD X deviation, and STD Y deviation with eyes open, and in trace length, C90 area, and STD velocity with eyes closed. No significant differences were observed in the analysis of the change in balance according to jump height.

According to multiple comparisons of trace length, C90 area, STD velocity, velocity, STD X deviation, and STD Y deviation with the eyes open, the results for the elastic taping condition and non-elastic taping condition were significantly lower than for the barefoot condition (Table 2). According to the multiple comparison analysis of trace length, C90 area, and STD velocity with eyes closed, the results for the elastic taping condition and non-elastic taping condition were significantly lower than for the barefoot condition (Table 3).

Table 2. The results of balance according to taping type and jump height (with eyes open)

Variables	Group	Jump	Mean ± SD		F	*P*
Trace length (mm)	BF[bc]	30 cm	1007.54 ± 283.82			
		38 cm	996.71 ± 197.96	Group	9.226	.000*
		46 cm	1076.87 ± 334.67			
	ET[a]	30 cm	887.26 ± 198.22			
		38 cm	896.36 ± 211.85	Jump	.022	.978
		46 cm	879.76 ± 172.59			
	NT[a]	30 cm	879.95 ± 251.82			
		38 cm	891.22 ± 192.94	Group*jump	.529	.715
		46 cm	837.64 ± 194.01			

Table 2. (Continued)

Variables	Group	Jump	Mean ± SD		F	*P*
C90 Area (mm^2)	BF[bc]	30 cm	887.16 ± 397.79	Group	12.275	.000*
		38 cm	1015.85 ± 438.39			
		46 cm	984.48 ± 575.49			
	ET[a]	30 cm	708.31 ± 279.72	Jump	.176	.839
		38 cm	696.77 ± 356.15			
		46 cm	685.84 ± 289.51			
	NT[a]	30 cm	674.41 ± 289.76	Group*jump	.280	.890
		38 cm	669.95 ± 276.91			
		46 cm	679.50 ± 308.27			
STD Velocity (mm/s)	BF[bc]	30 cm	20.77 ± 7.42	Group	14.636	.000*
		38 cm	21.85 ± 8.69			
		46 cm	24.77 ± 10.77			
	ET[a]	30 cm	16.49 ± 4.78	Jump	1.279	.281
		38 cm	15.91 ± 5.31			
		46 cm	16.97 ± 4.97			
	NT[a]	30 cm	16.20 ± 5.35	Group*jump	.674	.610
		38 cm	18.30 ± 6.15			
		46 cm	17.48 ± 5.62			
Velocity (mm/s)	BF	30 cm	335.58 ± 9.46	Group	14.528	.000*
		38 cm	33.22 ± 6.59			
		46 cm	65.89 ± 11.15			
	ET	30 cm	29.45 ± 6.65	Jump	.383	.682
		38 cm	29.61 ± 7.12			
		46 cm	29.3 ± 5.76			
	NT	30 cm	27.56 ± 6.54	Group*jump	.447	.774
		38 cm	29.70 ± 6.54			
		46 cm	28.83 ± 5.69			
STD X Deviation (mm/s)	BF[bc]	30 cm	5.91 ± 1.62	Group	5.366	.005*
		38 cm	6.57 ± 1.68			
		46 cm	5.72 ± 1.26			
	ET[a]	30 cm	5.46 ± 1.43	Jump	1.070	.345
		38 cm	5.38 ± 2.15			
		46 cm	4.90 ± 1.10			
	NT[a]	30 cm	5.14 ± 1.23	Group*jump	1.299	.272
		38 cm	5.81 ± 1.74			
		46 cm	5.45 ± 1.36			

Table 2. (Continued)

Variables	Group	Jump	Mean ± SD		F	P
STD Y Deviation (mm/s)	BF[bc]	30 cm	10.39 ± 2.93			
		38 cm	12.43 ± 4.62	Group	8.990	.000*
		46 cm	12.04 ± 4.48			
	ET[a]	30 cm	9.69 ± 2.83			
		38 cm	9.86 ± 4.23	Jump	.892	.412
		46 cm	9.67 ± 3.17			
	NT[a]	30 cm	9.06 ± 2.81			
		38 cm	8.69 ± 2.26	Group*jump	.897	.467
		46 cm	9.76 ± 3.37			

*P<.05
BF: Bare foot:[a], ET: Elastic taping:[b], NT: Non-elastic taping:[c]
C90 area: Minor ellipse area including 90% of center of pressure, STD velocity: Standard deviation velocity, STD X Deviation: Standard X Deviation, STD Y Deviation: Standard Y Deviation

Table 3. The results of balance according to taping type and jump height (with eyes closed)

Variables	Group	Jump	Mean ± SD		F	P
Trace length (mm)	BF[bc]	30 cm	1994.17 ± 465.30			
		38 cm	1821.44 ± 443.99	Group	5.615	.004*
		46 cm	2033.17 ± 499.36			
	ET[a]	30 cm	1610.32 ± 399.02			
		38 cm	1777.00 ± 815.48	Jump	.132	.876
		46 cm	1768.54 ± 581.20			
	NT[a]	30 cm	1668.51 ± 348.59			
		38 cm	1653.99 ± 710.20	Group*jump	.823	.512
		46 cm	1600.61 ± 315.09			
C90 Area (mm^2)	BF[bc]	30 cm	2436.17 ± 833.69			
		38 cm	1954.13 ± 626.21	Group	3.190	.043*
		46 cm	2326.76 ± 799.48			
	ET[a]	30 cm	1872.28 ± 889.74			
		38 cm	1916.57 ± 970.26	Jump	1.414	.412
		46 cm	2147.81 ± 1149.59			
	NT[a]	30 cm	1920.87 ± 684.01			
		38 cm	1811.94 ± 717.80	Group*jump	.643	.633
		46 cm	1926.95 ± 738.71			
STD Velocity (mm/s)	BF[bc]	30 cm	35.74 ± 10.05			
		38 cm	32.02 ± 9.23	Group	11.050	.000*
		46 cm	36.70 ± 10.33			
	ET[a]	30 cm	27.00 ± 7.42			
		38 cm	27.84 ± 9.01	Jump	2.154	.119
		46 cm	31.35 ± 11.65			
	NT[a]	30 cm	28.60 ± 8.06			
		38 cm	28.12 ± 6.74	Group*jump	.724	.576
		46 cm	29.67 ± 6.86			

Table 3. (Continued)

Variables	Group	Jump	Mean ± SD		F	P
Velocity (mm/s)	BF	30 cm	62.37 ± 17.22	Group	2.844	.061
		38 cm	62.96 ± 12.60			
		46 cm	65.57 ± 18.72			
	ET	30 cm	53.67 ± 13.30	Jump	.522	.170
		38 cm	53.76 ± 14.11			
		46 cm	70.21 ± 67.04			
	NT	30 cm	51.38 ± 13.51	Group*jump	.622	.647
		38 cm	51.79 ± 14.13			
		46 cm	54.86 ± 12.78			
STD X Deviation (mm/s)	BF[bc]	30 cm	10.26 ± 2.25	Group	.925	.398
		38 cm	9.60 ± 1.84			
		46 cm	10.26 ± 1.66			
	ET[a]	30 cm	9.05 ± 2.23	Jump	.522	.594
		38 cm	9.56 ± 2.58			
		46 cm	10.01 ± 3.18			
	NT[a]	30 cm	9.99 ± 1.95	Group*jump	.741	.565
		38 cm	9.34 ± 2.29			
		46 cm	9.44 ± 2.46			
STD Y Deviation (mm/s)	BF[bc]	30 cm	16.49 ± 4.72	Group	1.824	.164
		38 cm	14.22 ± 3.67			
		46 cm	15.93 ± 3.76			
	ET[a]	30 cm	14.19 ± 3.34	Jump	1.523	.221
		38 cm	13.86 ± 4.36			
		46 cm	14.96 ± 4.04			
	NT[a]	30 cm	14.77 ± 3.38	Group*jump	.513	.726
		38 cm	14.26 ± 3.83			
		46 cm	14.55 ± 3.71			

*$P<.05$
BF: Bare foot:[a], ET: Elastic taping:[b], NT: Non-elastic taping:[c]
C90 area: Minor ellipse area including 90% of center of pressure, STD velocity: Standard deviation velocity, STD X Deviation: Standard X Deviation, STD Y Deviation: Standard Y Deviation

DISCUSSION

In this study, the analysis of the change of balance according to taping type showed that balance with eyes open and closed in the elastic taping condition was significantly improved compared to in the bare-foot condition.

Previous studies have shown various results of taping. According to an analysis of the effect of elastic taping on balance for young male soccer players with FAI, applying elastic taping improved balance.[38] Analyzing the effect of elastic taping on balance for the ankle joint showed that balance was improved in the group for whom elastic taping had been applied compared to the non-applied group.[39] Balance was improved in the elastic taping group compared to the control group according to an analysis of the effect of elastic taping accompanied with a movable technique on balance in a study using a one-leg standing position for soccer players with FAI. This is due to the fact that elastic taping provides significant tension to the skin, thereby improving the proprioception, and the remodeling of the feedback circuit effectively worked to return the ankle joint to a stable state,[40] as the muscles are activated to prevent the excessive range of movement associated with impairment.[40,41] Finally, in a study of the time to stabilization for those with and without FAI, the FAI group took longer than the control group to stabilize in the anteroposterior direction landing after a jump.[42]

In the current study, a comparison of the change of balance according to the condition showed that balance with eyes open and closed was significantly improved in the elastic taping condition compared to the barefoot condition. It is thought that this is because enough tension was provided to the skin to activate the afferent nerves coming from the sensory receptors located in the epidermis and because proprioception was improved. To return to a stable state during landing after jumping, the feedback circuit was influenced by the coordination of the muscles around the ankle joint to limit the excessive range of movement of the ankle joint, which helped the stability of the posture. It is believed that this may have had a positive effect on balance by helping shorten the time it took to return to a stable state.

In this study, the balance with eyes open and closed of the non-elastic taping condition was significantly improved compared to the barefoot condition.

In a previous study, an analysis of the effect of applying elastic taping, non-elastic taping, and braces for those with and without CAI on partial kinematic variables of the foot during drop landing reported that taping effectively stabilized the midfoot in the non-elastic taping group with CAI.[12] Another study on the effect of non-elastic taping of ankle joints on posture stability during landing after jumping for athletes with FAI found that applying non-elastic taping reduced the anteroposterior pressure center variable and the internal and external pressure center variable. This is because the proprioceptor ability was activated in the process of bending the knee to the maximum when landing, and thus, non-elastic taping increased the stability of the ankle. When the body is swayed during landing after the jump, the center of the body reaches the limit of stability, and it is possible that this may produce a large external moment that reduces the stability of the body. The non-elastic taping group decreased the fluctuation of the body to go into a stable posture, which means non-elastic taping had a stabilizing effect.[43] Applying non-elastic taping during single-leg jump landings for subjects with CAI has reduced dorsiflexion and plantar flexion.[44] Non-elastic taping has significantly reduced maximal inversion during standing above the platform and lateral inclination[45] and may improve ankle muscle support during sudden fluctuation of inversion.[46] According to the counterirritant theory, excitation of mechanical receptors induces the release of enkephalin and inhibits the transmission of nociceptive signals during the application of taping.[47] Taping stimulates the muscle-skin mechanoreceptor,[48] activates sensory nerve cells that increase the potential sensitivity of the proprioceptor, and activates motor neurons to rapidly excite firing of the muscle spindle, which helps the stability of posture.[43]

In the current study, balance with eyes both open and closed was significantly improved in the non-elastic taping condition compared to the barefoot condition. Applying non-elastic taping sufficiently stabilized the middle foot portion of individuals with CAI. Thus, it is believed that this effectively moved the anteroposterior pressure center and the internal and external pressure as well as improved support for the ankle joint muscles.

In this study, a comparison of the changes of balance according to the taping type found no significant differences between the elastic taping condition and the non-elastic taping condition.

In a previous study, the functional performance improvement of balance of ankle joints was analyzed to determine the difference of the effect between elastic taping and non-elastic taping. As a result, elastic taping was found to have a better effect than non-elastic taping and the placebo, but both elastic taping and non-elastic taping had no significant effect on range of motion.[49] As a result of analyzing the effect of applying elastic taping and non-elastic taping on the stability of the ankle after jumping, with a focus on the effect of cutaneous stimulation, a change in ankle angle was observed in both elastic taping and non-elastic taping, but no significant difference was observed. It was reported that applying taping was not enough to limit the movement of the ankle joint. According to the analysis of the effect of elastic taping and non-elastic taping on the stability of the ankle when landing after the jump, with a focus on the muscle stimulation effect, both elastic taping and non-elastic taping have shown changes in the angle of the ankle joint, but no significant differences were observed. This is because applying taping was not enough to limit the movement of the ankle joint.[50] An analysis of the effect of elastic taping and non-elastic taping on balance, jump performance, ankle joint angle, and muscular endurance found that the angle of plantar flexion was significantly increased in the elastic taping group. There were no significant differences in the balance, jump performance, and the muscular endurance of both the elastic taping and non-elastic taping groups. A previous study reported that both elastic and non-elastic taping promoted motor unit firing and muscle recruitment after applying taping but did not affect functional movement.[51] An analysis of the effect of elastic taping on jump performance and balance showed that elastic taping is not useful for improving jump performance and is not different from non-elastic taping.[52] A study on the effect of applying ankle balance taping using elastic taping on balance and dorsiflexion range of movement with weight-bearing ankles found no significant difference in the balance and the dorsiflexion range of movement. Applying elastic taping did not show an immediate balance improvement due to the change in the angle of the hip and knee joints, but did find improved perception of the subjects regarding stability, relief, and confidence.[53]

In the current study, no significant difference was found between the elastic taping and non-elastic taping conditions. It is believed that this is because both taping types may be more positive than the barefoot condition in terms of the immediate effect of balance by promoting motor unit firing and muscle recruitment and can help improve the perception of stability, relief, and confidence, but the degree of limit of ankle joint movement was not enough to affect the functional movement, such as jump performance, in both types of taping conditions. Moreover, this limitation did not cause a difference in the change of the balance of young adults with CAI between the two taping conditions; therefore, the effect on balance was not improved.

In this study, an analysis of the change of balance according to jump height no significant difference was found.

In a previous study on the effect of the jump height on kinematic variables and energy release in the coronal plane of the lower extremity joints, joint power and eccentric power in jump heights of 30 and 60 cm were greater in the hip joint and knee joint than the ankle joint, and eccentric power increased as jump heights increased. This is because the hip and knee joints play a key role in the total energy release from the coronal plane as the vertical ground reaction increases, and the hip joint is the largest contributor to energy absorption, which refers to the priority strategy of the hip joint in the coronal plane corresponding to the maximum vertical ground reaction during landing.[54] Most of the energy for the jump comes from the hip muscles,[55] and the landing strategy in the coronal plane that reduces the risk of injury in the lower limbs maximizes the hip energy release with increased jump height and might also reduce the necessity of using the other two joints: the knee joint and ankle joint.[53] In FAI, the impairment of the output function of eccentric muscle power strength in the plantar flexor has appeared to be related to jump performance.[56] Postural control includes hip joint strategy and ankle strategy. Two strategies are commonly used to control the body movement of sagittal plane in order to restore balance. In the hip joint strategy, it is mainly recovered by the movement of the body around the hip joint. In the ankle joint strategy, it is mainly maintained or recovered by the movement of the body around the ankle such as inverted pendulum.[57]

In the current study, there were no significant differences in balance according to jump height. The result indicated that CAI may be limited to the eccentric output of the plantar flexor related to the jump movement when landing after the jump, but it is related to ankle joints rather than muscle impairment related to the hip joints outputting most energy for jump and impairment of proprioceptor. In this study, jump height increases the necessity of using hip joints rather than ankle joints, so it is thought that these subjects did not reach the change of balance according to the jump heights by selecting hip joint strategy as superior to ankle joint strategy for posture control related to jump height.

CONCLUSION

In this study, elastic taping and non-elastic taping were applied for young adults with CAI, and the change in balance with eyes open and closed when landing jumps was analyzed. According to an analysis of change of balance, a significant interaction effect was not found. The elastic taping condition and non-elastic taping condition improved the balance compared to the barefoot condition. A change in balance was not found according to jump heights.

Elastic taping and non-elastic taping help improve ankle joint function by positively affecting the proprioceptor such as muscle spindle and stabilization of the ankle joint. Based on these results, it may be possible to apply elastic and non-elastic taping to temporarily improve balance for subjects such as athletes and individuals with instability and impairment of the ankle joint, which may help enrich their performance.

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APPENDIX I Cumberland Ankle Instability Tool (CAIT)

Please tick the ONE statement in EACH question that BEST describes your ankles.		Left	Right	Score
1	I have pain in my ankle			
	Never			5
	During sport			4
	Running on uneven surfaces			3
	Running on level surfaces			2
	Walking on uneven surfaces			1
	Walking on level surfaces			0
2	My ankle feels UNSTABLE			
	Never			4
	Sometimes during sport (not every time)			3
	Frequently during sport (every time)			2
	Sometimes during daily activity			1
	Frequently during daily activity			0
3	When I make SHARP turns, my ankle feels UNSTABLE			
	Never			3
	Sometimes when running			2
	Often when running			1
	When walking			0

APPENDIX | Cumberland Ankle Instability Tool (CAIT)

	Please tick the ONE statement in EACH question that BEST describes your ankles.	Left	Right	Score
4	When going down the stairs, my ankle feels UNSTABLE			
	Never			3
	If I go fast			2
	Occasionally			1
	Always			0
5	My ankle feels UNSTABLE when			
	Never			2
	On the ball of my foot			1
	With my foot flat			0
6	My ankle feels UNSTABLE when			
	Never			3
	I hop from side to side			2
	I hop on the spot			1
	When I jump			0
7	My ankle feels UNSTABLE when			
	Never			4
	I run on uneven surfaces			3
	I jog on uneven surfaces			2
	I walk on uneven surfaces			1
	I walk on a flat surface			0
8	TYPICALLY, when I start to roll over (or “twist”) on my ankle, I can stop it			
	Immediately			3
	Often			2
	Sometimes			1
	Never			0
	I have never rolled over on my ankle			3
9	After a TYPICAL incident of my ankle rolling over, my ankle returns to “normal”			
	Almost immediately			3
	Less than one day			2
	1-2 days			1
	More than 2 days			0
	I have never rolled over on my ankle			3