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Original Article

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# Effects of an Exercise Program Incorporating Taping on Gait Ability in Patients with Stroke and Foot Drop

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**Purpose:** This study investigated the effect of an ankle joint exercise program incorporating taping on gait ability in stroke patients with foot drop.
**Methods:** Participants included 20 stroke patients with foot drop symptoms and were allocated to either an experimental group (n = 9) or a control group (n = 11). Gait ability was analyzed after a 4-week course of treatment applying the intervention for 30 minutes, 3 times per week.
**Results:** The timed up and go test (TUG) revealed significant differences between the groups ($p < 0.05$), and a significant difference between the groups only after the intervention ($p < 0.05$). Gait analysis revealed significant differences in the three variables of tempo, speed, and balance between the groups ($p < 0.05$), and only the tempo and speed variables were significantly different between the groups ($p < 0.05$).
**Conclusion:** This study confirms a positive effect of an ankle joint exercise program incorporating Kinesio taping on gait ability in stroke patients with foot drop.

**Keywords:** Stroke, Athletic tape, Exercise, Ankle joint, Gait

## INTRODUCTION

Stroke is a cerebrovascular event in which the blood supply to the brain is interrupted or brain tissue hemorrhages, resulting in loss of brain function.[1] Stroke is a frightening condition that affects one person every two seconds, with a stroke-related fatality every six seconds worldwide and 15 million new cases each year.[2] After a stroke, approximately 40% of patients experience functional impairment, and 15-30% experience severe motor, sensory, cognitive, perceptual, and speech impairment.[3,4] In particular, more than 85% of stroke patients experience hemiplegia, which results in impaired upper and lower extremity function and reduced motor skills.[5] These deficits are associated with poorer quality of life, impaired community reintegration[6], and increased risk of falls.[7]

Impaired ankle function is common in stroke patients and hinders the ability to walk.[8] The ankle joint allows the foot to flex, extend, and rotate, and it plays an important role in walking, running, and climbing stairs.[9] It is also one of the lower extremity kinetic chains and plays an important role in gait and various balancing activities.[10] However, in stroke patients, limited range of motion, muscle weakness, and ankle stiffness can cause prolonged impairment of balance, gait, and activities of daily living.[11] Stiffness, especially in the ankle, is speed-dependent and responds to the speed of movement by affecting reflexes, and these abnormal movements can contribute to further stiffening of the ankle.[12] As the stiffness increases, patients may develop deformities at the ankle, such as foot drop and supination, which negatively affect balance.[13,14]

Gait is an active exercise that involves maintaining balance and shifting the body's center of gravity.[15,16] Paralysis of the peroneal nerve is common after stroke, causing weakness in foot dorsiflexion.[17] This results in gait impairment caused by weakened or restricted dorsiflexion of the ankle during the swing phase of the gait cycle.[18] In addition, compared with non-hemiplegic patients, those with hemiplegia reported decreased gait speed and speed per minute, with increased lower limb support and bilat-

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eral support.[15,19] Therefore, mitigating the symptoms of foot drop after stroke is important for safe and efficient gait. However, approximately 50% of stroke survivors remain impaired in their ability to walk after six months of the current standard treatment.[18] Therefore, the development of innovative rehabilitation strategies to improve walking ability is one of the top research priorities in stroke care.[20]

The intervention in this study was the application of Kinesio tape according to muscle texture, which has the advantages of conformance to the body and non-interference with movement during exercise.[21] When applied to the teeth and touch points of the muscles, Kinesio taping can support the patient's active movement, relieve muscle tension, and correct the body. Therefore, when combined with other exercise programs, it is expected to improve proprioception in stroke patients.[21] Taping promotes ankle function by stimulating cutaneous receptors and supporting ankle movement, improving balance and gait in stroke patients.[22] Furthermore, the combination of exercise therapy and Kinesio taping has produced greater interventional improvements than either exercise therapy alone.[23] In particular, the application of taping to the lower extremity muscles during proprioceptive intervention is effective in improving balance.[24] In a treadmill gait intervention for stroke patients with foot drop, Kinesio taping improves the activity of the tibialis anterior, peroneus longus, and hallux valgus muscles, as well as ankle angle and gait velocity, compared with ankle orthoses.[25]

Although various attempts have been made to apply exercise therapy and interventions using assistive devices to stroke patients, there is a relative lack of research on combining exercise therapy and taping at the same time, and it is worthwhile to study the effect of applying various treatment methods and application sites. Therefore, the purpose of this study was to determine the effect of combining ankle joint exercise program and kinesio taping on walking ability in stroke patients and to provide useful data.

## METHODS

### 1. Participants

In this study, a total of 30 stroke patients with foot drop symptoms admitted to a hospital in Seoul, Korea, were allocated to experimental (n = 15) or control (n = 15) groups using a random allocation software program. During the study, 6 patients in the experimental group and 4 patients in the control group dropped out for personal and discharge reasons, leaving 9 patients in the experimental group and 11 patients in the control group. All participants were informed of the experimental procedure before participation and provided voluntary consent. The consent form included information about the anonymity and confidentiality of the individual's personal details and information, and the right to withdraw from the study at any time, depending on the patient's circumstances and condition. To ensure the confidentiality of the participants' data, the research data were analyzed and destroyed.

### 2. Experimental methods

#### 1) Gait ability

##### (1) Timed up and go test

The timed up and go (TUG) test is a way to quickly measure mobility and gait ability. The participant starts from a position seated in a chair, arises and walks a distance of 3m, and returns to the chair; the time required for the participant to complete these maneuvers is recorded. The average of three TUG test results is then calculated. The test has a retest reliability of 0.99 and an inter-rater reliability of 0.98, making it a valuable tool.[26]

##### (2) Gait analysis (Human tract)

The gait analyzer (Human tract HT-GATS, RBiotec, Hwaseong, Korea) is an apparatus that can automatically calculate three-dimensional joint angles and parameters using an IMU sensor, Stereo Vision Sensor, and Main System Requirement to diagnose the cause and degree of gait disorders based on joint angle information. The gait analyzer uses a wireless software program and attaches a total of 7 sensors perpendicular to the ground, with straps applied to the participant's 2nd metatarsal bone, the tibia 9cm below the knee, the femur 9cm above the knee, and the iliac crest. The participant is asked to walk a distance of 5m to measure spatial and temporal patterns, gait symmetry, and lower limb joint angles. Among the gait abilities, tempo, speed, and balance index were measured in this study, and the average value of three measurements was used.

### 3. Intervention

#### 1) Ankle joint exercise program

The intervention protocol of this study was based on that of previous studies and included a 4-week intervention period and an ankle joint exercise program.[27,28] All participants received the same ankle joint exercise program, and the intervention period was 4 weeks, 3 times per week, 30 minutes per session. The participant assumed a seated position and the therapist adjusted the alignment of the participant's knee and ankle joints, then grasped and lengthened the shortened gastrocnemius and soleus muscles on the hemiplegic side to achieve medial alignment.[27] To


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Table 1. Ankle joint exercise program

| Type | Position | Program | Time | Intensity (RPE) | Frequency |
|---|---|---|---|---|---|
| Exercise | Supine | Affected side L/E re-alignment & Taping applying | | | |
| | Supine & Sitting | Ankle dorsi flexion, eversion<br>Sit to stand training | 30 min | 13-14 RPE | 30 min, 3 time/wk, 4 wk |
| | Standing | Gait training | | | |

L/E: Lower-Extremity, RPE: Rating of Perceived Exertion.

lengthen the shortened Achilles tendon, we performed repeated plantarflexion and dorsiflexion by grasping the ankle at the top of the Achilles tendon on the hemiplegic side, followed by dorsiflexor muscle strengthening interventions by grasping the patient's heel with one hand and the toe area with the other hand to maintain alignment.[28] The height of the chair and the position of the feet were adjusted to maximize activation of the dorsiflexor muscle. The therapist assisted the hip and knee joints of the participants during the sit-to-stand training. The experimental group performed the exercise program after taping, while the control group performed the exercise program alone (Table 1). During all interventions, adequate breaks were provided upon the participant's request.

#### 2) Kinesio taping

Kinesio taping in the experimental group was applied by the same clinical physiotherapist at approximately 80% tension to the tibialis anterior, peroneus longus, and peroneus brevis muscles on the affected side with the ankle joint in neutral position while sitting (Figure 1). The tibialis anterior muscle originated from the lateral tibial epicondyle, through the interosseous membrane between the tibia and fibula, and attached to the first metatarsal bone. The peroneus longus and brevis muscles originated from the fibular head, extended along the fibula, and attached on the fourth and fifth metatarsal bones. The students were instructed to remove the Kinesio taping within 6 hours of application.[29]

Figure 1. Tibialis anterior muscle, Peroneus longus and brevis muscle taping applying

### 4. Data analysis

Descriptive statistics (mean ± standard deviation, SD) for the measured items were calculated using SPSS 22.0 for Windows (IBM Corp., Armonk, NY, USA). Normality of data distribution was determined using the Shapiro–Wilk test, and none of the data were normally distributed. The general characteristics of the study participants were tested for homogeneity using Levene's test. The Mann–Whitney U test was used to compare differences between groups, and the Wilcoxon signed rank test was used to compare changes from pre- to post-intervention. The level of statistical significance was set at 0.05.

## RESULTS

### 1. General characteristics of the study participants

The general characteristics of the study participants are listed in Table 2. All were tested for homogeneity, and no statistically significant differences were observed ($p > 0.05$).

### 2. Comparison of TUG test results

There was a significant difference between groups in the TUG test results (3m)($p < 0.05$). The difference between groups was significant only after the intervention ($p < 0.05$)(Table 3).

Table 2. General characteristic of subject (n=20)

| | EG (n=9) | CG (n=11) | p |
|---|---|---|---|
| Sex (male/female) | 7/2 | 9/2 | |
| Age (year) | 53.7±7.2 | 63.3±14.9 | 0.833 |
| MAS (grade) | 1±0.7 | 0.8±0.9 | 0.610 |
| MMSE-K (score) | 26.7±1.8 | 27.2±1.6 | 0.621 |
| Hemi side (left/right) | 4/5 | 3/8 | 0.450 |
| Pathology type (infarction/hemorrhage) | 5/4 | 3/8 | 0.086 |

Mean±standard deviation. EG: Experimental Group, CG: Control Group, MAS: Modified Ashworth Scale, MMSE-K: Mini-Mental State Exam-Korean.

Table 3. Comparison of timed up and go test

| | Pre | Post | z (p) |
|---|---|---|---|
| EG (n=9) | 50.64±25.04 | 40.96±22.86 | -2.666 (0.008*) |
| CG (n=11) | 76.60±25.44 | 71.88±24.08 | -2.934 (0.003*) |
| z (p) | -1.785 (0.074) | -2.545 (0.011*) | |

Mean±standard deviation. EG: Experimental Group, CG: Control Group. *p<0.05.

### 3. Comparison of gait abilities (tempo, speed, balance) using gait analysis

Gait analysis revealed significant differences between the three variables of tempo, speed, and balance in gait ability ($p < 0.05$), and there were significant differences between the groups only in the tempo and speed variables ($p < 0.05$)(Table 4).

Table 4. Comparison of gait ability (tempo, speed, balance)

| Variables | | Pre | Post | p |
|---|---|---|---|---|
| Tempo (step/min) | EG (n=9) | 67.14±19.23 | 80.74±17.60 | 0.008* |
| | CG (n=11) | 51.90±24.85 | 56.71±22.89 | 0.013* |
| | z (p) | -1.557 (0.119) | -2.204 (0.028*) | |
| Speed (m/s) | EG (n=9) | 0.550±0.128 | 0.822±0.167 | 0.008* |
| | CG (n=11) | 0.521±0.164 | 0.594±0.200 | 0.003* |
| | z (p) | -0.723 (0.469) | -2.395 (0.017*) | |
| Balance | EG (n=9) | 80.42±12.27 | 88.01±9.08 | 0.008* |
| | CG (n=11) | 79.19±11.45 | 81.60±10.91 | 0.003* |
| | z (p) | -0.532 (0.595) | -1.633 (0.102) | |

Mean±standard deviation. EG: Experimental Group, CG: Control Group. *p<0.05.

## DISCUSSION

Taping interventions are used by physical therapists to promote and inhibit muscle activity, immobilize joints, assist with movement, provide strength, and manage pain, and are used by a wide range of younger and older populations, including those with musculoskeletal and neurological disorders.[30,31] Studies have shown benefits for balance and strength in young adults, and for pain control in middle-aged and older adults.[32] However, domestic and international meta-analyses of studies analyzing Kinesio taping of the ankle alone have reported no evidence of effectiveness.[27,30] As Kinesio taping has expanded in scope and populations, debate continues about its effectiveness.

Therefore, this study investigated the effect of combining an ankle joint exercise program and Kinesio taping on gait ability in stroke patients with foot drop symptoms and to provide clinically useful data. After random group allocation, the experimental group applied Kinesio taping and the ankle joint exercise program, and the control group applied only the ankle joint exercise program. After 4 weeks, the TUG test (3m) and gait analysis (Human Tract) were used to measure the tempo, speed, and balance of the gait ability, and the results before and after the intervention were compared.

In the present study, there was a significant difference between time periods in the TUG test, and a significant difference between groups only after the intervention. Studies have reported significant differences in TUG test results when applying Kinesio taping and the proprioceptive neuromuscular facilitation technique to the lower extremities[33], along with positive effects when applying Kinesio taping to the plegic side of the ankle.[34] Our results are consistent with those of previous studies and suggest that interventions combining Kinesio taping and exercise programs are more effective in improving gait in stroke patients.

There were significant differences between time periods in the three variables of tempo, speed, and balance, and significant differences between groups in only tempo and speed. Stroke patients have reduced weight-bearing capacity in the paralyzed leg, and the reduced weight-bearing capacity leads them to use a hip strategy rather than an ankle strategy. As a result, they compensate by shifting their center of gravity more during walking, resulting in less stability, inefficient movements, and decreased gait tempo and speed. In particular, stroke patients with foot drop symptoms have a decreased ability to move forward at the ankle joint and a decreased instep flexion movement. Effect size analyses comparing pre- and post-Kinesio taping have reported large effect sizes for tempo and speed in gait.[35,36] The intervention, which consisted of an ankle joint exercise program and taping, was thought to improve walking ability by activating functional movements at the ankle joint, such as anterior-posterior movement and coordination. The results support previous studies. Only balance showed no significant change between groups. This is because Kinezio taping is not meant to immobilize the ankle joint, but rather to support movement and promote ankle function, so it is unlikely


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to be effective in balance, which is a gait skill that requires stability.

In conclusion, the results of this study demonstrated that an ankle joint exercise program combined with taping can activate functional movement at the ankle joint in stroke patients with foot drop, resulting in positive changes in walking ability. Based on the useful results obtained in this study, it is necessary to continue research on various effective physical therapy interventions that combine Kinesio taping with appropriate exercise programs.

This study was limited by the small number of participants and the inclusion of patients admitted to only a single medical center, which limits its generalizability. Also, the failure to apply evaluator blindness to the It remains a limitation.

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