Immediate Effects of Kinesio Taping of Tibialis Anterior and Ankle Joint on Mobility and Balance Ability for Chronic Hemiparesis: Randomized Controlled Cross-Sectional Design

Sofortige Effekte von Kinesio-Taping des vorderen Schienbeinmuskels und des Sprunggelenks auf die Mobilität und die Gleichgewichtsfähigkeit bei chronischer Hemiparese: eine randomisierte Querschnittsstudie

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Keywords
kinesio taping, TUDS, Balance, Stroke

Schlüsselwörter
Kinesio-Taping, TUDS, Gleichgewicht, Schlaganfall

received 16.11.2019
accepted 19.02.2020
online publiziert 01.04.2020

Bibliography
Phys Med Rehab Kuror 2020; 30: 350–357
DOI 10.1055/a-1126-4616
ISSN 0940-6689

Georg Thieme Verlag KG, Rüdigerstraße 14,
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ABSTRACT

Background Stroke patients with hemiparesis are generally described as being slow and suffering a balance disability.
Objective The purpose of this cross-sectional single-blind study was to evaluate the immediate effects of Kinesio taping of tibialis anterior and quadriceps on the mobility and balance ability in individuals with chronic hemiparetic stroke.
Methods Thirty-three subjects participated in this study. Participants were divided into 3 groups: Ankle Kinesio taping (AKT) group, a placebo (PKT) group, and a control (NKT) group. The AKT group underwent Kinesio tapping of ankle joint and tibialis muscle, PKT group underwent placebo taping, and NKT group underwent no Kinesio taping. All participants were assessed before and after taping training using timed up and go test (TUG), timed up and down stairs test (TUDS), and balance ability.
Results After taping training, the AKT group showed significant improvement in mobility and balance ability compared to the PKT group and NKT group ($p < 0.05$). The results of this study confirmed that Kinesio taping was effective to the balance and mobility abilities of patients with chronic hemiparetic stroke.
Conclusions This study suggested Kinesio taping as an effective intervention to increase the mobility and balance abilities of patients with chronic hemiparetic stroke. Therefore, this study are believed to provide the baseline information to effectively improve the balance and mobility abilities of patients with chronic hemiparetic stroke during the rehabilitation treatment in the future.

ZUSAMMENFASSUNG

Hintergrund Schlaganfallpatienten mit einer Hemiparese zeigen im Allgemeinen eine verlangsamte Mobilität und verminderte Gleichgewichtsfähigkeit.
Ziel Diese Studie hatte zum Ziel, die unmittelbaren Effekte von Kinesio-Taping des vorderen Schienbeinmuskels und des Sprunggelenks auf die Mobilität und die Gleichgewichtsfähigkeit von chronischen Schlaganfall-Patienten mit Hemiparese zu beurteilen.
Methoden Es nahmen 33 Patienten an der Studie teil. Die Teilnehmer wurden in 3 Gruppen aufgeteilt: eine Gruppe mit Kinesio-Taping des Sprunggelenks (AKT), eine Placebo Gruppe (PKT) und eine Kontrollgruppe (NKT). Die AKT-Gruppe erhielt Kinesio-Taping des Sprunggelenks und des vorderen Schien-

beinmuskels, die PKT-Gruppe erhielt Placebo-Taping und die NKT Gruppe erhielt kein Taping. Alle Teilnehmer wurden vor und nach dem Taping-Training mittels Timed up and go test (TUG), Timed up and down stairs test (TUDS), und Gleichgewichtstest untersucht.

Ergebnisse Die AKT-Gruppe (Taping des Sprunggelenks) zeigte nach dem Taping-Training im Vergleich zur Placebo- und zur Kontrollgruppe eine signifikante Verbesserung der Mobilität und der Gleichgewichtsfähigkeit ($p < 0,05$). Die Ergebnisse dieser Studie bestätigten, dass Kinesio-Taping die Gleichgewichtsfähigkeit und die Mobilität von chronischen Schlaganfallpatienten mit Hemiparese verbessert.

Schlussfolgerung Diese Studie zeigt, dass Kinesio-Taping eine effektive Therapiemöglichkeit ist, um die Mobilität und die Gleichgewichtsfähigkeit von chronischen Schlaganfallpatienten mit Hemiparese zu verbessern.

Die Ergebnisse belegen, dass mittels Kinesio-Taping die Gleichgewichtsfähigkeit und die Mobilität von chronischen Schlaganfallpatienten mit Hemiparese während der Reha-Behandlung verbessert werden kann.

Introduction

Stroke patients is one of the central nervous system diseases. It causes functional problems and loss of body functions to the brain because of the insufficient blood supply to the brain due to ischemia or bleeding [1]. It can induce muscle function, balance ability, communication disorders, depression, and cognitive disorders [2, 3].

Patients with chronic hemiparetic stroke tend to support 60–80 % of the body weight with the unaffected side of the lower extremity and it causes an asymmetrical standing posture [4, 5]. Moreover, 84 % of patients with cerebral infarction showed contracture on more than one joint and 76 % of them had an ankle issue [6]. The ankle joint supports the weight of the body and it promotes the sensory input and sensory feedback from the sole of the foot [7]. The ankle controls the balance and first responds even to a small change of the body. Therefore, ankle rehabilitation is essential for rehabilitating patients with cerebral infarction [8]. One of the most common changes in the foot and the foot complex after stroke is the foot drop of the ankle [9]. This deformation disturbs the movement of dorsaiflexion and plantarflexion during walking so it seriously affects the standing posture and walking [10].

Walking includes various situations such as walking on the flat surface, walking on the rolling terrain, and walking on the stairs [11]. When one goes up the stairs, the concentric contraction of the ankle and the knee are generated forward and upward. When the unaffected side goes to the swing phase, the stance phase of the affected side lower extremity requires great stability. When one goes down the stairs, the eccentric contraction of the hip joint, the knee joint, and the ankle joint occurs and they restrain the acceleration of the body due to the gravity [12]. The social participation and daily life of the patients are highly constrained [13, 14].

KT has been used as an auxiliary tool in a variety of rehabilitation programs, including the strengthening of weakened muscle, the control of joint instability and muscle tension, postural alignment assistance, alleviation of soft tissue inflammation and pain, mitigation of excessive muscle strain, and improvement of the range of motion [15–19]. Kilbreath et al. (2006) recently applied gluteal taping and placebo taping to patients with cerebral infarction (50 subjects in each group) and found that the gluteal taping group showed significantly different walking speed and significantly different stride of the affected and unaffected sides [20]. Moreover, Refshauge et al (2000) reported that the taping in contact intensifies the transmission of a skin-receptor signal, enhances proprioception and promotes the proper alignment of joints. Consequently, it can improve the balance and walking ability by increasing the stability of the ankle joints [21]. Rojhani-Shirazi et al. (2015) conducted KT by dividing 40 patients with cerebral infarction with and without KT on the ankle once a week for six weeks. Their results revealed that the group with KT had significantly better scores in the Berg balance scale and TUG [22].

Walking up and down stairs is closely related to the reciprocal pattern during the stance and swing phase. When walking up stairs, the concentric flexion of muscles in the knee and ankle joint occurs to move the body forward and upward [12]. During the single leg stance phase, the lower extremity bearing the body weight requires the most stability as well as the enhancement of the proprioceptive sensation.

The training of a patient to walk up and down stairs is greatly influenced by ankle movements and visual detection [23–25]. Additionally, patients face much more challenges and need to give more efforts while conducting stair gait training than walking training on a flat-surface level. Chen (2014) compared TUG and TUDS with and without wearing anterior ankle braces and showed that the group wearing the brace had significantly higher values. This study focused on increasing the stability of the ankle joint by applying Kinesio taping, which can have a similar function with the brace [11].

Previous studies have evaluated the various application methods of KT to the ankle of patients with the neurologic disorder and the effects of KT on the balance and walking by comparing it with the AFO. However, the previous studies have not examined the going up and down the stairs of patients with cerebral infarction in the actual clinical practice, when KT is applied to these patients. The purpose of this study was to determine the effects of KT on mobility and balance ability in individuals with chronic hemiparetic stroke. This study hypothesized that KT of Tibialis anterior would improve the mobility and balance ability of participants compared to PKT and NKT group.

Methods

Participants

This study was conducted on 33 patients with chronic hemiparetic stroke who satisfied the selection criteria and were hospitalized in M Hospital, Changwon-si City, Gyeongsangnam-do Province. Inclusion criteria for participants consisted of: (1) diagnosis of first onset of unilateral hemisphere stroke > 6 months ago, (2) had

MMSE score 24 or more, (3) could go up and down the stair independently or under supervision (able to go up and down with holding a cane or the rail), and (4) were medically stable. Exclusion criteria consisted of: (1) musculoskeletal diseases, cardiovascular diseases, (2) visual impairment, and (3) skin disease. Informed consent was voluntarily obtained from all patients before participation in the study, and this study was recived approval from the Gimcheon University Institutional Review Borad. (GU-201801-HRa-01–02).

Procedure.

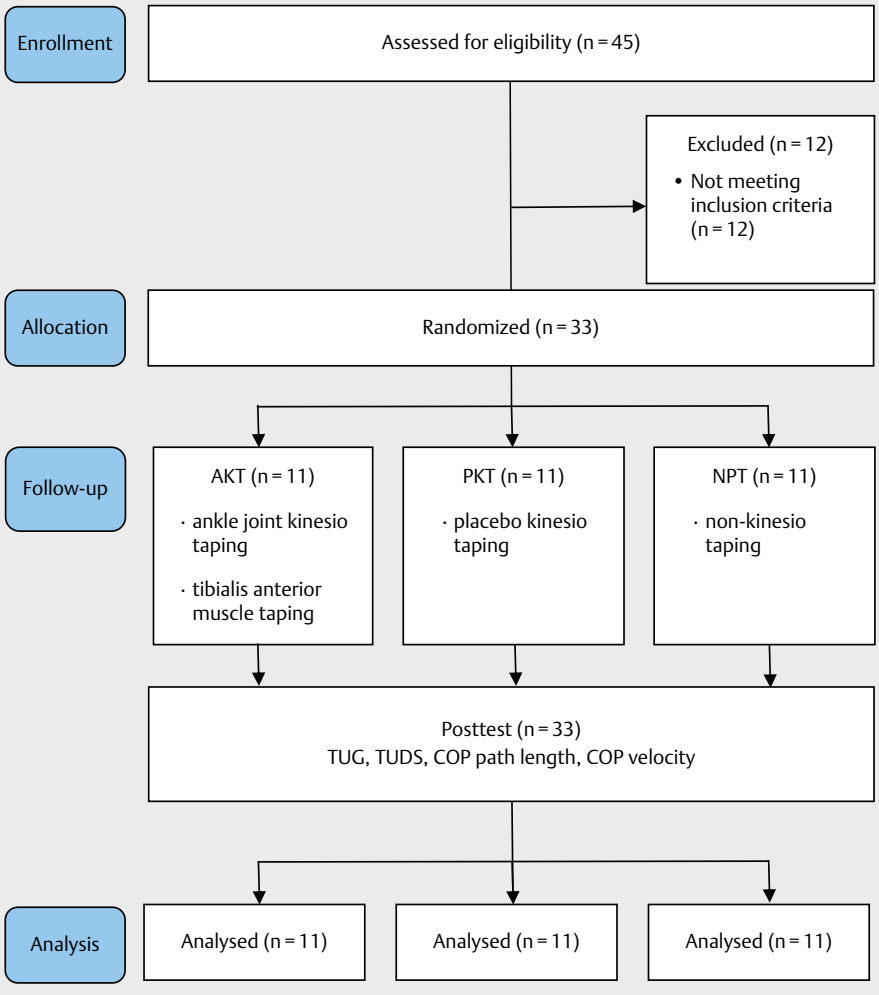
To perform a sample size, the G * Power 3.1 software was calculated. The alpha levels set at 0.60 and 0.50, respectively, and the effect size of 0.80, 11 group members were selected.

33 participants met the selection creatia and were randomly divied into the 3 group. de. In order to minimize the selection bias, the random grouping used envelops. Ankle taping was applied to the patients in the AKT group and placebo ankle taping was applied to the patients in the PKT group. The NKT group was a control group (▶ **Fig 1**). The TUG, TUDS and balance, were measured for participants with and without taping. TUG and TUDS were examined for the mobility. COP path length and COP velocity were recorded for balance by using force plate.

Intervention

Interventions using the KT (BB Tape, WETAPE Inc., Seoul, Republic of Korea) were applied to the AKT group, PKT, and NKT group by physical therapist. All KT treatments were performed by the physical therapist, who had more than 10 years of experience. In the AKT group, taping was applied from the muscle of tibialis anterior to insersion first without stretching the tape [26]. The application of eversion taping was conducting while one therapist had the participants feet flexed and valgus and the other therapist applied KT from the 2–3cm front of the medial malleolus to the 2–3cm front of the lateral malleolus via the sole of the foot. The taping was applied 3 times with overlapping ½ each time. Taping was applied from a far side to a near side of the ankle [22]. The participant was allowed to maintain dorsiflexion and eversion during taping (▶ **Fig 2**).

In the PKT group, a tape was attached only on the front of the lateral malleolus, in the manner as kinesio tape, for placebo effect (▶ **Fig 2**). In the NKT group was tested without taping.



▶ **Fig. 1** Flow diagram of total experimental procedure.

Ankle kinesio taping group | Placebo taping group

▶ **Fig. 2** Kinesio taping technique.

Measurement

One physical therapists who were blinded to the 3 groups allocation of paticipants assessed all measurement.

Mobility ability

The TUG test was conducted to assess the dynamic balance ability of stroke patients. The TUG test measures how long it takes for a subject, who sits on a chair with armrests on a flat floor, to get up at the signal of "Start", walk 3m forward, come back, and sit back on the chair. The time was measured 3 times for each patient using a stopwatch and the mean value of them was used for the study. The test and re-test of patients with cerebral infarction showed a good correlation (r = 0.95) [27].

TUDS test included Walking up and down stairs , which had a total of 13 steps, high, wide, and deep of 16, 130, and 30cm respectively. It measured the time taking for both feet to travel from the bottom of the steps to the top of the steps and the time taking for both feet to move from the top of the steps to the bottom of the steps. Two times were added and used for the study. In order to increase the reliability, it was measured twice and the mean value was used [11, 28].

Balance ability

This study evaluated the balance ability using the force plate of Nintendo Wii Balance Board. The test results were processed using Balancia software program (Balancia 2.0 ver. Mintosys, KR). This satisfies all parts of the force plate. The force plate, which was used in this study, had total 1,504 pressure sensors installed, 1 per 1 cm^2 on the 32 × 47 cm^2 plate. It measures the movement of pressure center at the static position. The pressure range was 1–120 N/cm^2 and the speed of static sample pressure extraction was 2–5 Hz. The speed of dynamic sample pressure extraction was approximately 90 Hz with the accuracy of ± 5 %. A subject was asked to stand on the force place with barefoot in the most comfortable position with having the subject's arms down and maintaining the position. The feet positions were recorded and the subject was asked to place the feet on the same position during the re-examination. With considering the height of each participant, a dot with a diameter of 15 cm was set and each subject was asked to gaze the dot, which was located at 3m in front of the subject with eyes open [29, 30]. In order to minimize the muscle fatigue, each subject took a rest for 3 min between each measurement. Each variable was measured 3 times before and after the intervention and the mean value of 3 measurements was used for the analysis. Intra-rater reliability (ICC) was between 0.89 and 0.79, intra-rater reliability (ICC) was between 0.70 and 0.92, and validity (ICC) was between 0.73 and 0.87 [31].

Data Analysis

Data analysis was performed using Predictive Analytics Soft Ware (PASW) for windows Version 21.0(SPSS Inc., Chicago IL, USA). For normality testing, the Kolmogorov-Smirnov test was used. For difference in variance among the 3 groups before and after training, one-way ANOVA was used: for post hoc analysis, the Tukey test was used. The statistical significance of the data was accepted at values of α = 0.05

Results

General characteristics

The general characteristics of the study subjects are shown in ▶ **Table 1**. No significant group differences were observed in height, weight, age, MMES-K, onset, gender, diagnosis, affected side, and brain lesion location.

Changes in the mobility ability

After KT training, TUG and TUDS were significantly different among the 3 groups. The TUG in the AKT group (change values 5.50 sec,) showed significantly greater improvement in comparison to that of the PKT group (change values 0.68 sec,) and NKT group (change values 0.49 sec,) after the kinesio taping training (F = 4.133, d.f. = 2, p = 0.026) (▶ **Table 2**, ▶ **Fig 3**).

The TUDS in the AKT group (change values 7.06 sec) showed significantly greater improvement in comparison to that of the PKT group (change values 0.90 sec) and NKT group (change values 0.39 sec) after the kinesio taping training (F = 4.351, d.f. = 2, p = 0.022) (▶ **Table 2**, ▶ **Fig 3**).

▶ **Table 1** General Characteristics of Subjects.

	AKT group (n = 11)	PKT group (n = 11)	NKT group (n = 11)	$F/ X^2(p)$
Height (cm)	165.63 ± 3.89 *	167.86 ± 4.73	165.41 ± 6.24	0.794(0.461) [a]
Weight (kg)	70.75 ± 9.17	67.35 ± 8.79	66.34 ± 6.18	0.881(0.425) [a]
Age (year)	54.18 ± 11.16	59.36 ± 12.89	57.73 ± 10.67	0.572(0.570) [a]
MMSE-K (score)	27.00 ± 1.73	27.09 ± 2.12	27.45 ± 2.07	0.162(0.851) [a]
Onset (months)	13.64 ± 2.46	13.73 ± 2.72	12.91 ± 2.26	0.357(0.702) [a]
Gender				
Male	6(54.5%)	5(45.5%)	6(54.5%)	0.243(0.886) [b]
Female	5(45.5%)	6(54.5%)	5(45.5%)	
Diagnosis				
Infarction	7(63.6%)	5(45.5%)	5(45.5%)	0.971(0.616) [b]
Hemorrhage	4(36.4%)	6(54.5%)	6(54.5%)	
Affected side				
Left	7(63.6%)	6(54.5%)	6(54.5%)	0.248(0.883) [b]
Right	4(36.4%)	5(45.5%)	5(45.5%)	
Brain lesion location				
Cortex	2(18.2%)	2(18.2%)	2(18.2%)	0.318(0.989) [b]
subcortex	5(45.5%)	6(54.5%)	6(54.5%)	
Mixed TUDs	4(36.4%)	3(27.3%)	3(27.3%)	

▶ **Table 2** Comparison pre-test and post-test among 3 group.

Variables	AKT group (A) (n = 11)		PKT group (B) (n = 11)		NKT group (C) (n = 11)		P
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	
TUG (sec)	20.44 ± 5.53	14.94 ± 3.24	20.91 ± 5.73	20.23 ± 5.64	20.73 ± 5.85	20.24 ± 5.68	0.026 A>B,C
TUDS (sec)	44.86 ± 4.31	37.79 ± 3.50	43.67 ± 4.04	42.77 ± 4.04	42.94 ± 5.51	42.54 ± 5.60	0.022 A>B,C

Changes in the COP path length and COP velocity

The COP path length in the AKT group (change values 5.83 cm) showed significantly greater improvement in comparison to that of the PKT group (change values 1.50 cm) and NKT group (change values 1.31 cm) after the kinesio taping training (F = 4.614, d.f. = 2, p = 0.018) (▶ **Table 3**, ▶ **Fig 3**).

The COP velocity in the AKT group (change values 0.55 cm/s) showed significantly greater improvement in comparison to that of the PKT group (change values 0.02 cm/s) and NKT group (change values 0.02 cm/s) after the kinesio taping training (F = 4.335, d.f. = 2, p = 0.022) (▶ **Table 3**, ▶ **Fig 3**).

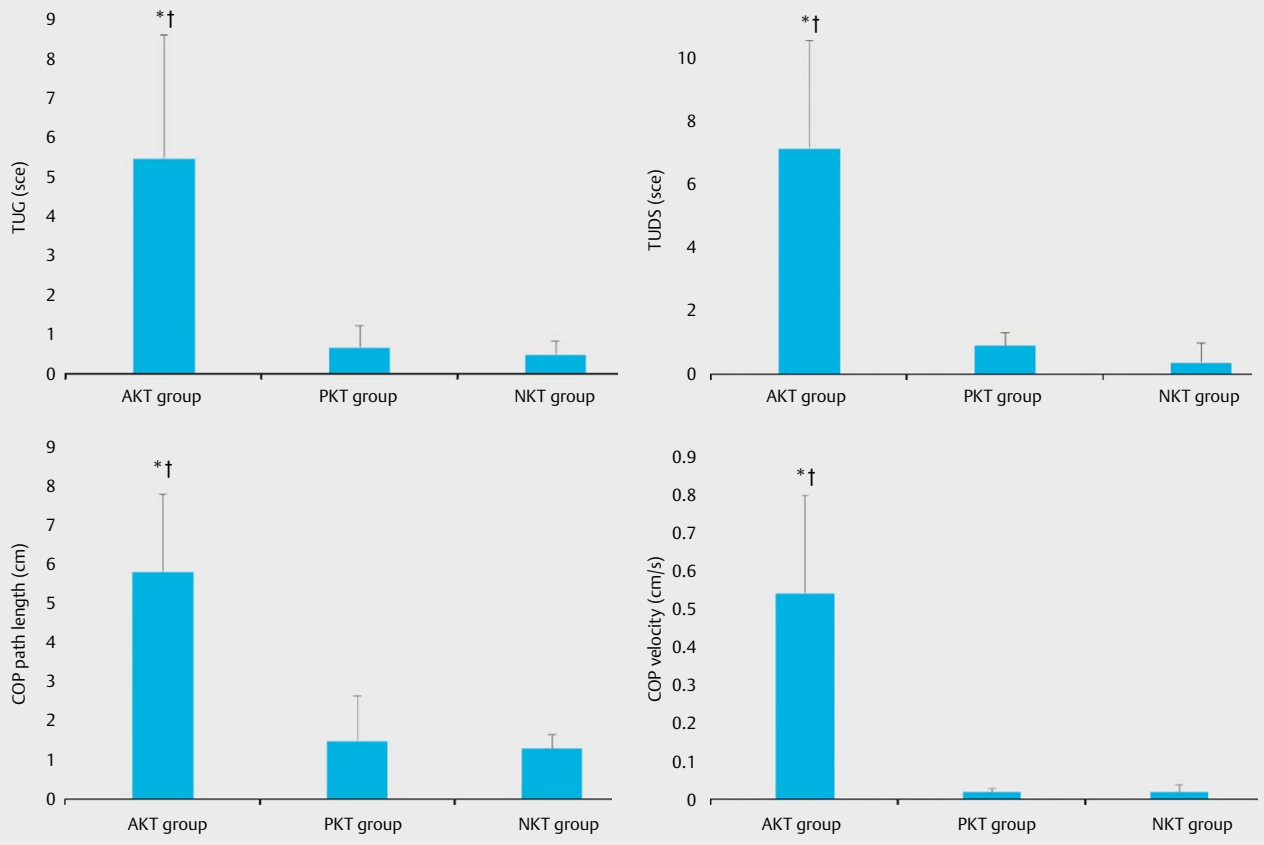
Discussion

The results of recent studies showed that application of brace to the ankle deformity used to be common but studies sought to find alternatives of it due to various shortfalls of it [32]. The ankle intervention using KT for patients with cerebral infarction has been widely studied [33].

The objective of this study was to evaluate the effects of KT application to the ankle on the balance and mobility of patients with chronic cerebral infarction instantly. This study applied KT to the ankle joint and analyzed the effects of KT on the mobility and balance ability.

The reason for using KT is because of increase the range of motion and improve the dorsiflexion the ankle joint by taping. Overlapping KT contributes to increased stability of the ankle joint.

Anyone can apply taping and it takes little effort and a small amount of time to apply it, which are merits of taping. Moreover, the application of taping allows functional movements since it supports the joint and protects the joint. Additionally, the external support reinforces the ligaments and restricts the movement to improve the stability of the joint, which is a merit of taping [34].



▶ **Fig. 3** Change values of balance and mobility ability in participants. TUG, timed up and go test; TUDS, timed up and down stairs test; COP path length, center of pressure path length; COP velocity, center of pressure velocity; AKT group, ankle kinesio taping group; PKT group, placebo kinesio taping group; NKT, non-kinesio taping group. *Significant difference compared with NKT group ($p<0.05$). †Significant difference compared with PKT group ($p<0.05$).

▶ **Table 3** Comparison pre-test and post-test among 3 group.

Variables	AKT group (A) (n = 11)		PKT group (B) (n = 11)		NKT group (C) (n = 11)		P
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	
COP path length (cm)	84.80 ± 5.35	78.97 ± 5.56	86.90 ± 6.59	85.40 ± 6.24	86.65 ± 5.70	85.34 ± 5.25	0.018 A > B,C
COP velocity (cm/s)	3.58 ± 0.58	3.03 ± 0.42	3.57 ± 0.50	3.54 ± 0.50	3.54 ± 0.47	3.52 ± 0.46	0.022 A > B,C

This study applied KT to the tibialis anterior and valgus in relation to the ankle joints of patients with chronic hemiparetic stroke Moreover, this study randomly divided 33 patients with hemiparetic stroke into 3 experimental groups. The evaluators evaluated the dependent variable blindly.

The results of the present study showed that force plate, TUG, and TUDS of the AKT group were significantly different from those of the PKT group and the NKT group. The difference could be because KT was effective in regulating the musculoskeletal system of the knee and ankle joints by providing ceaseless stimulus to these areas through the skin and increasing the sensory input [35]. Moreover, this study applied taping to correct the position of equinus. It is believed that the application aligned the ankle joint to the normal position and it was effective to increase the sensory input through the sole of the foot and improve the movement and function of the foot [36].

The function of gastrocnemius and the tibialis anterior affects the forward and backward movement. The function of tibialis anterior is to maintain the stability while the feet touch the ground during the support phase and pull the ground during the swing phase. Because the tibialis anterior balances the opposite ankle and leg while the foot is on the ground, it helps the leg keep vertical to the ground even when walking on uneven ground. Thus, activation

of the tibialis anterior muscle is very important to the stability of the ankle and proprioception.

Stroke survivors have limited independent mobility and their tibialis anterior muscle are weakened during the swing phase. On the affected side, the tibialis anterior muscle is activated late and the activation period is short during the support phase. Moreover, the simultaneous activation of the tibialis anterior muscle and the gastrocnemius is shortened in this side [35, 37, 38]. Therefore, inducing the muscle contraction by increasing the activation of the tibialis anterior muscle is important to the drop foot and to the stability and proprioception of the ankle. Moreover, it optimizes walking [26]. Moreover, the position of the foot is closer to the flexion of the dorsiflexion during the swing phase. Therefore, it could be effective for walking by reducing the compensation effect of the knee joint and hip joint. Moreover, as far we are aware of, this is the first study to measure TUDS after applying KT to the ankle joint of patients with cerebral infarction. TUDS is a tool for evaluating the ability to going up and down the stairs and it is an essential item for a patient with cerebral infarction to return to the everyday life. The application of KT showed a significant effect in TUDS evaluation. When going up the stairs, the dragging of a foot causes the compensation of the knee and hip joints and it brings the balance of the body backward. Therefore, it poses a risk of falling and the stairs become an obstacle to a patient [11]. The results of this study implied that the application of KT reduced the dragging of the foot, decreased the compensation of the knee and hip joints, and placed the leg joints to the right position while going down the stairs. Therefore, the wide part of the foot touched the stairs to maintain the balance effectively.

There were several limitations to this study. First, this study focused on the spontaneous effects of KT application. Therefore, it was impossible to know the functional aspects of patients with chronic hemiparetic stroke when KT was applied for a long time. Second, generalizing the study results is limited because the number of participants was too small. It may be difficult to expect the same results for acute and subacute stroke patients. Third, this study did not measure energy consumption efficiency, joint angle, muscle activity, and muscle fatigue, which are biomechanical variables. Therefore, diverse studies should be conducted in the future to scientifically prove the effects of it in the rehabilitation treatment program for enhancing the mobility and improving balance abilityof patients with cerebral infarction by supplementing these limitations.

Conclusion

The results of this study proved that KT was an effective intervention method to improve the balance and mobility of patients with chronic hemiparetic stroke. The results of this study suggested that KT can be an important intervention tool for a therapist to apply for patients with chronic hemiparetic stroke.

Acknowledgments

This work was supported by the Gimcheon University Research Grant.

Conflict of Interest

The authors declare that there were no conflict of interest

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