The effect of the Kinesio taping at the leg on compensatory movement during walking in individuals with stroke

Anecha Horasart[1], Sunee Bovonsunthonchai[1*], Wanalee Klomjai[1]

[1]Faculty of Physical therapy Mahidol University, Salaya, Phutthamonthon,

Nakhon Pathom, 73170, Thailand

[*]Corresponding author. Tel.: +668 9812 8744, E-mail: sunee.bov@mahidol.edu

ABSTRACT

In walking of individuals with stroke, they usually present compensatory movement of the hip, knee, and ankle, instead of having normal movement. These problems may reduce the ability of daily living activities and increase the risk of fall. Therefore, present study aimed to investigate the effect of the Kinesio taping at the leg on compensatory movement during walking in individuals with stroke. Fourteen individuals with stroke participated in the study, classified into 11 males and 3 females. Their mean age was 57.42 ± 12.25 years and mean onset was 9.00 ± 5.57 months. Participants were assessed gait performance by using 3D motion analysis system at pre- and post-taping. Techniques of taping included 1) functional correction technique for the ankle dorsiflexion and pronation 2) inhibition technique at the ankle plantarflexors muscle. Averaged data from 3 gait trials were used in the analysis. The results showed significant improvement ($p < 0.05$) of gait speed, affected step length, single support time, and the ankle dorsiflexion after applying kinesio taping. In conclusion, the Kinesio taping may improve some gait performance but may not enough to reduce gait compensation significantly. Hence, a larger number of participants and long-term study is needed to investigate the effect of KT.

Keywords: Stroke, Gait, Compensatory movement, Kinesio Taping

1. INTRODUCTION

Stroke is a cerebrovascular disease caused by ischemic or hemorrhagic stroke. It leads to bodily functional loss that being control by the brain [1]. Stroke is a major health burden worldwide and in Thailand. It common cause of disability among elderly people, often resulting dependence in activities of daily living [2]. After a stroke, more than eight percent of individuals with stroke have motor impairments of lower extremity including muscle weakness, altered muscle tone, and abnormal synergistic pattern. These impairments can contribute to the development of compensatory movement [3].

Gait deviation can observe in stance and/or swing phases. The most common gait compensation pattern of individuals with stroke was circumduction gait that increased hip abduction and external rotation. In addition, knee hyperextension at the terminal stance and ankle supination during swing and stance phases were found. These compensations assist toes clearance during a swing phase

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of gait [1, 3, 4]. Although the compensatory movement may help individuals with stroke to be able to perform daily activities, it can cause mal-adaptive brain plasticity in long-term of motor recovery and increased energy expenditure [Takeuchi, 2012 #257][5]. This abnormality results from weakness of ankle dorsiflexor muscles and/or excessive activity of ankle plantarflexor muscle. The ankle joint plays an important role in locomotion function not only supports the body during weight loading but also provides sensory information during walking. Therefore, strengthening of muscle and improvement of range of motion of the ankle are required to improve balance and gait ability [6].

Main goals of individuals with stroke and caregivers are able to walk and perform activity daily living independently. Thus, many rehabilitation programs have been used, focusing on gait improvements such as bobath technique, proprioceptive neuromuscular facilitation (PNF), treadmill gait training, robotic gait training, functional electrical stimulation (FES), and assistive device application [7]. However, limitations of these rehabilitation techniques may include high cost, a range of motion limitation, and specialist dependency.

Recently, the Kinesio taping (KT) is another technique to improve proprioception, muscle activity, and joint alignment adjustment. It can be useful and have been proved for functional improvement and disability reduction [8]. KT frequency uses in sports, musculoskeletal, and neurological conditions [9]. In the previous study, application of KT has been reported to improve balance ability and gait performance [10]. In 2015, Kim et al. studied the effect of KT which applied around ankle joint compared with ankle-foot orthosis (AFO) on gait ability in individuals with stroke who have foot drop. Improvement in muscle activities of tibialis anterior and rectus femoris muscles and increased ankle joint angle in the KT group were found. The authors described that KT application improved range of motion in the attachment areas and improvements of ankle joint stability and muscle activity [11]. In addition, Park et al. found improvement in gait ability after taping immediately on the quadriceps and tibialis anterior muscles [12].

Even though the improvements of cadence, gait speed, stride length, and ankle joint angle were found in the previous studies, but lack of information about the decrement of compensatory movement. Therefore, this study aimed to investigate the reduction of compensatory movement after applying Kinesio taping at the leg in individuals with stroke.

2. MATERIALS AND METHODS

The study design was a pre-post study design. Individuals with stroke were recruited from the Physical Therapy Center, Faculty of Physical Therapy, and Mahidol University. Prior to participating in the study, participants signed the informed consent which was approved by the institutional ethical committee (MU-IRB 2017/010.1701).

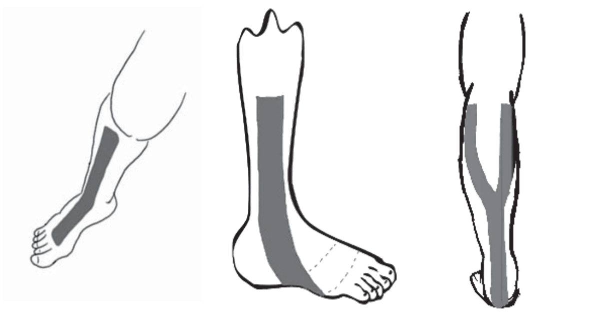
The inclusion criteria were age between 20-80 years, first stroke with onset between 1 month to 2 years, present observable gait problems such as insufficient ankle dorsiflexion, toe drag, abnormal foot supination during swing or stance phases of gait, mild spasticity of ankle plantarflexors, ankle invertors, hip adductor, and hip extensor muscles testing by the Modified Ashworth Scale (MAS $\leq$ 2 scores), ability to walk at least 10 meters with or without using a cane, understand instructions and follow the research protocols, no cognitive impairment testing by the Thai Mental State Examination (TMSE > 23 scores), normal or partial impairment of proprioceptive sense at the ankle joint and exteroceptive sense at foot and leg areas. Participants were excluded if they have visual deficits, ankle joint contracture, opened wound at the shank, calf, and foot, and have other neurological conditions.

Screening following the criteria, demographic recording, and physical examination was performed before beginning data collection.

2.1 Data collection protocol

Walking data were collected twice which were before and immediately after applied KT by 10 cameras of the Vicon™ Motion Analysis System (T20-series). Prior to data collection, system and participant calibrations were performed. Sixteen retro-reflective markers were attached to the participants' body following the lower body Plug-in-gait model.

Participants walked with their bare feet along the 8 meters walkway. They were asked to walk through the capture area at their own comfortable speed for 3 trials. All walking data were recorded with a frequency of 100 Hz. A physical therapist walked beside the participants to prevent falling or any hazardous situation.



Functional correction technique for ankle dorsiflexor muscle	Functional correction technique for ankle supinator muscle	Inhibition technique for gastrocnemi us muscle

Figure 1. The Kinesio Tape application around the ankle joint.

KT with 5 cm dimension was used in this study. KT with functional correction technique was attached to ankle dorsiflexor and pronator muscles and inhibition technique was attached to gastrocnemius muscle (Figure 1).

2.2 Data processing and deduction

Gait data were selected at the middle part of walkway and gait events were tracked in accordance with foot markers. Butterworth filtering technique with cut off frequency at 6 Hz was applied. Kinematic variables were processed using the Nexus software.

2.3 Outcome variables

The values of temporo-spatial variables and kinematic variables were determined. For temporo-spatial variables included the step length (m), gait speed (m/s), single support time (% Gait Cycle: %GC) and double support time (%GC). For kinematic, variables included peak hip flexion (degree) at mid-swing, peak hip extension (degree) at pre-swing, peak hip abduction (degree) at mid-swing, peak hip external rotation (degree) at mid swing, peak knee flexion (degree) at mid-swing, peak knee extension (degree) at terminal stance, peak ankle dorsiflexion (degree) at initial contact, peak ankle plantarflexion (degree) at pre-swing, peak ankle supination (degree) at initial contact.

2.4 Data Analyses

The sample size is calculated based on our own pilot study (n = 5), with a set of 80 % statistical power and 5 % significance level and showing the number of the participant of 14.

The Kolmogorov Smirnov Goodness of Fit test was used to assess the distribution of the data and expressed with non-normality. The Wilcoxon Signed Rank test was used to compare the data between before and immediately after applied KT. All data were tested with statistical significance at $p < 0.05$.

3. RESULTS

Demographic data are presented in Table 1. Fourteen patients with stroke participated in the study. They were eleventh males and three females classified into the right (n = 2) and left (n = 12) sides affected. Their averaged age was 57.42 ± 12.25 years and stroke onset was 9.00 ± 5.57 months. Averaged TMSE and Fugl Myer Assessment (FMA) were 29.21 ± 0.97 and 28.71 ± 4.15 scores. The MAS scores of hip adductor, hip extensor, knee extensor, ankle plantarflexors, and ankle invertor muscles were 0.28 ± 0.61, 0.28 ± 0.61, 0.71 ± 0.73, 1.35 ± 1.33, 0.57 ± 0.64, respectively.

Table 1. Demographic characteristic of participants.

Variables	Values (number or mean ± SD)
Male/Female (n)	11 / 3
Affected side (Rt. / Lt.) (n)	2 / 12
Age (years)	57.42 ± 12.25
Onset (months)	9.00 ± 5.57
TMSE (scores)	29.21 ± 0.97
FMA (scores)	28.71 ± 4.15
MAS of hip adductor (scores)	0.28 ± 0.61
MAS of hip extensor (scores)	0.28 ± 0.61
MAS of knee extensor (scores)	0.71 ± 0.73
MAS of ankle plantarflexors (scores)	1.35 ± 1.33
MAS of ankle invertor (scores)	0.57 ± 0.64

TMSE: Thai Mental State Examination, FMA: Fugl Meyer Assessment scale, MAS: Modified Ashworth Scale

Table 2 shows the comparison of temporo-spatial variables between before and after immediately applied KT. There were significant differences of the step length (p = 0.003), gait speed (p = 0.030) and single support time (p = 0.002) between before and immediately after applied KT.

Table 2. Comparison of temporo-spatial variables between before and after immediately applied KT

Variables	Before applied KT (Mean ± SD)	After immediately applied KT (Mean ± SD)	p-value
Gait speed (m/s)	0.41 ± 0.26	0.46 ± 0.25	0.003*
Step length (s)	0.31 ± 0.12	0.34 ± 0.10	0.030*
Single support time (%GC)	21.63 ± 8.00	24.29 ± 7.62	0.002*
Double support time (%GC)	42.10 ± 12.50	39.35± 11.72	0.060

*Significant difference tested by the Wilcoxon signed rank test at $p < 0.05$

Table 3 shows the comparison of kinematic variables in sagittal plane between before and immediately after applied KT. There were significant differences in the peak ankle dorsiflexion (p = 0.011).

Table 3. Comparison of kinematic variables in sagittal plane between before and immediately after applied KT.

Sagittal plane	Before applied KT (Mean ± SD)	After immediately applied KT (Mean ± SD)	p-value
Peak hip flexion	12.43 ±7.82	12.11 ±7.85	0.826
Peak hip extension	16.54 ± 8.84	17.09 ± 8.89	0.433
Peak knee flexion	28.36 ± 17.37	28.27 ± 16.56	0.975
Peak knee extension	5.74 ± 6.17	5.64 ± 6.43	0.975
Peak ankle dorsiflexion	12.28 ± 7.26	15.15 ± 8.44	0.011*
Peak ankle plantar flexion	8.19 ± 9.99	6.39 ± 10.08	0.109

*Significant difference tested by the Wilcoxon signed rank test at $p < 0.05$

Table 4 shows the comparison of compensatory movement between before and immediately after applied KT. There was no significant difference in the peak hip abduction, peak hip external rotation, peak knee extension, and peak ankle supination ($p > 0.05$).

Table 4. Comparison of compensatory movement between before and immediately after applied KT.

Sagittal plane	Before applied KT (Mean ± SD)	After immediately applied KT (Mean ± SD)	p-value
Peak hip abduction	3.30 ± 3.30	3.17 ± 3.91	0.363
Peak hip external-rotation	16.31 ±19.37	16.31±19.73	0.331
Peak knee extension	5.74 ± 6.17	5.64 ± 6.43	0.975
Peak ankle supination	6.27 ±19.09	5.02 ± 22.59	0.778

*Significant difference tested by the Wilcoxon signed rank test at $p < 0.05$.

4. DISCUSSION

The aim of this study was to investigate the reduction of compensatory movement after applying KT at the leg in individuals with stroke. We hypothesized that the compensatory movement may be reduced after KT application. However, the results showed no significant reduction of compensatory movements during walking after KT application. Considering the alterations of temporo-spatial and kinematic data during gait, we found the improvements of gait speed, step length, single support time, and peak ankle dorsiflexion after applied KT.

For the improvements of temporo-spatials, this was supported by the study of Shirazi et al. in 2015 [13]. They applied KT on the ankle joint to correct excessive ankle supination and found that postural balance and function were improved. They concluded that KT may provide cutaneous cues while talipes eqinovarus was corrected, then the joint ROM and function were improved. Moreover, KT may explain by better co-contraction of the muscles around the ankle and increase ankle muscle strength which led to the improvement of postural control [6]. In addition, KT may improve the heel to contact and reduce the duration of the step and the swing phases, with the reduction of the overall duration of the gait cycle in consequently [14]. Therefore, the benefit of KT may provide improvements of gait speed, step length, and single support time. For the improvements of the kinematics, only the peak ankle dorsiflexion at initial contact was significantly improved. Whereas, peaks of hip flexion, hip extension, knee flexion, knee extension, and ankle plantar flexion did not found the change. The Functional correction may provide sensory stimulation in order to assist movement and acted as passive assist on taping target [8]. According to Callaghan et al. [15] study, they reported the improvements of ROM depended on attachment area of KT application. This happening may come from improvements of proprioceptive sensation and muscle activity. KT stimulated skin mechanoreceptors through stretch and pressure that increase cutaneous fusiomotor reflex and then activated afferent sensory nerve activity [16]. Improvement of muscles activity was occurred by excitation of gramma motor nerves in skeletal muscle, as the tension of the fiber was raised at the taping area [17].

The previous study found that ankle dorsiflexion was importance to walk as a normal gait pattern [18]. To achieve foot clearance, compensatory movement such as hip abduction during swing phase was used during gait and excessive circumduction movement occurred during fast walking speed [18]. Zollo et al. in 2015 [19] applied the AFO in individuals with stroke who had foot drop. They found that compensatory movement was reduced but no significant difference between control and AFO group. Similar to this study, there was no significant reduction of compensatory movements (peak hip abduction, peak hip external rotation, peak knee extension, peak ankle supination) after KT application. However, we found the only minor tendency of compensatory movement reductions of peak ankle supination around 1 degree. This accompanied with significantly increased ankle dorsiflexion angle which very important for foot clearance. Moreover, the result was the immediate effect of KT and taping only on the ankle. Gait behavior with a reduction of reduced compensation may require more time to enhance.

5. CONCLUSION

The findings of this study indicated that the KT applications with functional correction technique for ankle dorsiflexion and pronation and inhibition technique at gastrocnemius muscle were effective for improvement of gait speed, affected step length, single support time and ankle dorsiflexion but the evidence was insufficient to reduce gait compensation in individuals with stroke. Therefore, a larger number of samples and longer duration of application may need to investigate the effect of KT.

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