Immediate Effect of Elastic Taping Application on Gait Functional Ability in Patients with Stroke

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Abstract

Background: The typical consequence of a stroke is the limitation in walking ability. In stroke patients, there is a disruption of mobilization, including walking. Stroke patients exhibit abnormal walking patterns as compensation for muscular weakness. Elastic taping is known to increase functional movement through increased muscle strength; elastic taping helps maintain muscle coordination of agonists, synergists, and antagonists. **Objective:** Determine the immediate effect of elastic tape on the gait functional ability in post stroke patient with ankle dorsiflexor muscle weakness. **Method:** This research is an experimental pre-post study. The total subjects are 11 patients with hemiparesis following stroke. The gait speed, step length and stride length measured by gait analysis lab with CMAX gait software, before and after the elastic tape application for 30 minutes. Leukotape K® was applied with facilitation technique on the anterior tibial and extensor digitorum longus, from the origin to the insertion with 100% of stretch. **Result:** The gait speed and step length on healthy side after 30 minutes elastic tape increased when compared with the pre-application value ($p>0.05$). **Conclusion:** There is an increment of gait speed and step length on healthy side in post-stroke patients with ankle dorsiflexor weakness after 30 minutes elastic taping application. Elastic taping may be beneficial in treating gait functional disturbances in post-stroke patients.

INTRODUCTION

Stroke is a major cause of long-term disability and has significant socioeconomic consequences. The incidence of stroke affects approximately 15 million people worldwide per year, with 5 million dying as well as 5 million experiencing residual symptoms and permanent disability. In the Western world, stroke is the third most common cause of death and considered as the single most important cause of severe disability in people living in their own homes (Carr et al., 2010). According to the Basic Health Research data of 2013, the prevalence of stroke in Indonesia is 12.1 per 1000 population (Riskesdas, 2013). The number of surviving patients after stroke has increased, leading to more people living with physical, mental, and social impairment (Boeskov et al., 2014).

The typical consequence of a stroke is the limitation in walking ability. In stroke patients there is a disruption of mobilization, including walking, with this disorder most important in daily activities. Stroke patients exhibit abnormal walking patterns as compensation for muscular weakness and balance disorders. This occurs because of the disruption of weight shifting capabilities that are symmetrical because of the weakening of the accelerating power of the paresis's lower limb (Pearson et al., 2004).

The daily activities of stroke patients are limited by walking difficulties. In a safe and normal gait cycle, the ankle dorsiflexor muscles play an important role. After a stroke, these muscles undergo partial or total paresis, which causes the patient to have difficulty conducting ground clearance during the swing phase, and may result in inefficient gait compensation such as circumcision or hip hiking. This abnormal road pattern will increase energy demand, decrease endurance, and increased risk of falls, and may ultimately reduce the quality of life of post-stroke patients (Woo-IL et al., 2014).

The main focus in physical therapy for patients with stroke is the optimization of functional motor skills. Functional improvement in stroke patients is primarily determined by exercise intensity, task specificity, and duration of therapy. Thus, modalities or methods are able to facilitate improved motor function and can intensify functional motor skills training, one of which increasingly needed walking ability (Van Peppen et al., 2004).

Elastic taping is an increasingly used therapeutic tool in the rehabilitation of musculoskeletal disorders. In the 1980s, elastic taping was first used in the sports arena; in recent years, has been used in the rehabilitation of patients with neurologic disorders. Elastic taping is easy to apply including by the patient's own, non-invasive, and inexpensive; in addition, the application of elastic taping also does not waste time. Elastic taping, attached to the skin, gives cutaneous nociceptive signals, stimulating proprioceptive so that the identification of the joint position becomes more appropriate. Elastic taping is also known to effectively increase functional movement through increased muscle strength and endurance. In addition, elastic taping helps maintain muscle coordination of agonists, synergists, and antagonists through muscle tone control (Boeskov et al., 2014).

Despite the increasing popularity and many benefits of elastic taping put forward, the beneficial effects of elastic taping have not been supported by sufficient scientific evidence. Theoretically, the right application can facilitate weak muscles or relax the overused muscles, inhibit pain, increase proprioception, facilitate and inhibit muscle activity and increase lymphatic drainage and blood flow. The use of elastic taping is most effective in cases where pathological conditions occur, although clinical benefit remains to be demonstrated in high-quality studies. Yasukawa and colleagues examined the effect of elastic taping on functional motor skills in children with various neurological diseases and reported an association between elastic taping of upper limbs and improvement of hand and arm functional skills (Yasukawa et al., 2006). Maguire and colleagues examined the taping effect of gluteus medius muscle at walking speed in patients with stroke and observed an increased walking rate with taping, indicating that elastic taping improved motor function in patients with stroke (Maguire et al., 2010).

This study aims to analyze the effects of elastic taping on the ankle dorsiflexor muscles on the functional capability of post-stroke patients using a walking test on an 8-meter course.

METHODS

This research is an experimental pre-post study. The subjects are patients who met the inclusion criteria and did not meet the exclusion criteria, consecutively came to Rehabilitation Outpatient Clinic of Dr. Soetomo General Hospital from September to October 2017. The inclusion criteria are patient with hemiparesis following stroke, onset more than two weeks, able to maintain standing position and can walk independently at least 10 meters, stable with or without ambulation aid, muscle strength of ankle dorsiflexor at least 2, able to understand a simple command, and agree to participate in the study by signing the informed consent. Patients will be excluded if there is a severe hemispatial neglect, cardiorespiratory disruption, and skin lesion on lower leg and ankle. Patient who has hypersensitivity to the elastic tape will be dropped out from the study. The magenta color was chosen because of the effect of facilitation. The gait speed, step length and stride length measured by CMAX gait software. The step length is is linear distance in the plane of progression between corresponding successive contact points of opposite feet; The stride length is linear distance between corresponding successive points of contact of the same foot. The examination was performed before, and after the elastic tape application for 30 minutes. Leukotape K® produced by BSN Medical, magenta and 5 cm wide, was applied with facilitation technique on the anterior tibial and extensor digitorum longus from the origin to the insertion with 100% of stretch. The statistical analisis in this study is using SPSS 22.0. Paired t-test is used to compare the gait speed, step length, stride length before and after the application of elastic taping for 30 minutes. This research approved by the ethics committee of the Dr. Soetomo Hospital Surabaya (Ethics Code Number: 613/Panke.KKE/X/2017).

Table 1. Characteristic of The Subjects

Characteristic	N	Min	Max	Mean ± SD
Subject	11			
Age (year)		24	72	52.73 ± 13.92
Sex				
Man	10 (90.9%)			
Woman	1 (9.1%)			
Stroke Onset(months)		7	36	25.27 ± 11.88
Body Weight (kg)		40.5	113	63.68 ± 21.83
Body Height (m)		1.49	1.82	1.63 ± 0.11
BMI (kg/m²)		16.56	34.88	23.45 ± 5.33

Table 2. Characteristic of Stroke

	Frequency	Percentage
Type of Stroke		
• Infarct	10	90.9%
• Bleeding	1	9.1%
Paretic Side		
• Right	5	45.5%
• Left	6	54.5%
Stroke Attack		
• First	10	90.0%
• Second	1	9.1%
MMT of Ankle Dorsiflexor		
• 2	6	54.5%
• 3	1	9.1%
• 4	4	36.4%

Table 3. Mean Differences of Gait Speed Before and 30 Minutes After Elastic Tape Application

	Pre Taping	Taping 30 min	Δ Mean ± SD	*P* value
Gait Speed (m/s)	0.86 ± 0.44	1.01 ± 0.54	0.15 ± 0.15	0.007*

p is the level of significance tested by paired t test, *p* value <0.05 is considered significant (*)

Table 4. Gait Speed of each subject before and after elastic taping application

Speed pre (m/s)	Speed post (m/s)	Δ Speed (m/s)
1,318	1,519	0,200
0,651	0,728	0,077
0,467	0,597	0,131
1,154	1,272	0,118
0,297	0,313	0,016
1,032	1,121	0,090
0,524	0,532	0,008
1,611	1,840	0,229
0,298	0,33	0,032
1,062	1,288	0,227
1,073	1,588	0,515

Table 5. Mean Differences of the step length paretic side and healthy side before and after Elastic Tape Application

	Pre Taping	Taping 30 min	Δ Mean ± SD	*P* value
St L P>H	62.78 ± 22.79	64.80 ± 19.19	2.02 ± 9.79	0.51
St L H>P	58.71 ± 19.39	64.02 ± 22.08	5.31 ± 5.82	0.013*

St L P>H = Step length of paretic side to healthy side; St L H>P = Step length of healthy side to paretic side; step length on centimeter (cm); *p* is the level of significance tested by paired t test, *p* value <0.05 is considered significant (*)

Table 6. Mean Differences of the stride length paretic side and healthy side before and after Elastic Tape Application

	Pre Taping	Taping 30 min	Δ Mean ± SD	*P* value
SL P (cm)	120.23 ± 36.03	126.33 ± 19.19	6.10 ± 12.48	0.136
SL H (cm)	118.88 ± 38.44	126.45 ± 39.59	7.56 ± 11.74	0.058

SL P = Stride length of paretic side; SL H = Stride length of healthy side; Stride length on centimeter (cm)
p is the level of significance tested by paired t test, *p* value <0.05 is considered significant (*)

RESULTS

Total subjects are 11 patients consisting of 10 men and 1 women, with characteristic shown on table 1 and 2. Table 3, 5, and 6 shows the gait speed, step length and stride length, before and after elastic tape application for 30 minutes. Measurement of gait speed before elastic taping application showed that there were 6 (54.5%) subjects in the category of full community ambulation (mild impairment) with walking speed >0.8 m/s; 3 (27.3%) subjects were in the category of limited community ambulation (moderate impairment), gait speeds in the range 0.4 to 0.8 m/s; and 2 subjects (18.2%) in the household ambulation category (severe impairment) with gait speed <0.4 m/s. After elastic taping application for 30 minutes changes in gait speed not changed the classification of ambulation of research subjects (Table 4). The increase of walking speed passing MCID value, that is 0.175 m/s, only experienced by 4 research subjects all in the category of full community ambulation.

The step length paretic side after 30 minutes application increases when compared with the pre-application value but not statistically significant (*p*> 0,05). The step length healthy side after 30 minutes application increases when compared with the pre-application. The stride length paretic and healthy side after 30 minutes application increases when compared with the pre-application value but not statistically significant (*p*> 0,05). No side effects were reported and found, so there was no drop out. No subject is uncomforted with elastic tape.

DISCUSSION

Gait Speed Before and After Elastic Taping Application for 30 Minutes

The results of this study indicate a significant increase in mean walking speed at a 30-minute measurement after elastic taping of the anterior tibialis and extensor digitorum longus. The mean value of walking speed after application was higher with mean difference of 0.15 ± 0.15 m/s (p = 0.007). All subjects (11 of 11) obtained an increase in gait speed with the smallest value difference of 0.008 m/s and the largest difference value of 0.52 m/s. The immediate effect on the expected increase in expected speed has been obtained within 30 minutes after the application.

The elastic taping application for 30 minutes of gait speed does not change the classification of ambulation of the research subjects. Increasing the speed of walking through the MCID value is also only experienced by 4 research subjects who are all in the category of full community ambulation. Research conducted by Maguire and colleagues also showed a similar thing. Taping applied to the hip abductor muscles gives immediate effect, increased walking speed although intervention has no effect on changing the different gait functional categories (Maguire et al., 2010).

The increase in walking speed after taping in this study has several explanations. Elastic taping provides continuous stretching of the skin, which stimulates the cutaneous mechanoreceptors resulting in physiological changes in the taping area. Mechanoreceptor stimulation may increase proprioceptive input to muscle to improve task-specific function. Taping attached to the skin stimulates different sensory receptors, increasing the contraction ability of the leg muscles (Yoshida and Kahanov, 2007; Kaya Kara et al., 2014).

This study is also in line with previous research conducted by Boeskov et al (2014) who achieved maximum walking speed with a 10 meter (10MWT) walking test with a 0.08 m/s difference after kinesthetic tape application on the anterior part of the thigh and paresis leg limbs (Boeskov, et al., 2014). Elastic taping may provide greater proprioceptive input to the skin, which may lead to improvement in motor function (Boeskov et al., 2014).

A similar hypothesis to elastic taping action mechanisms that can play the role of a sensitive input integrated by the central nervous system and used to assist the process of motor program execution known as sensorimotor integration (Camerota et al., 2015).

The increase in walking speed in this study was accompanied by a step-step improvement in healthy side that showed increased walking speed with bipedal support. Increased step length on the healthy side can affect the significant change in walking speed. Another possibility is that even with substandard step and stride lengths, the subjects were able to execute steps with less time.

In this study, significant increases in walking speed were not accompanied by statistically significant increases in some other variables, these results are similar to studies conducted by Myoung-Kwon and colleagues (2015). One reason for the lack of alterations likely to be due to lack of research is to consider or assume differences in the limb lengths of each subject and the characteristics of different subject gait (Myoung-Kwon and Hyun-Gyu, 2015).

The results of this study also correspond to a significant increase in pre and immediate post application elastic taping with spring-assist techniques in anterior tibialis muscle performed by Parab and colleagues (2017) where there are significant differences seen in pre- and post-application applications at speed runs with p value 0.0098. The spring-assist technique or functional correction technique utilizes mechanical and sensorimotor stimuli to facilitate the ankle dorsiflexor muscle. Proprioceptive serves to direct or orientate the body in space. Through the mechanoreceptors, there is a sense of position and movement of the joints. Proprioceptive input from the mechanoreceptors is involved in the control of the postural motor system. The sensors are present in the joints, muscles, tendons, and on the skin. Through this mechanism, more information is available on the position and movement of the transmitted limbs and extremities (Parab et al., 2017).

Ankle dorsiflexor muscles also play an important role by working eccentrically. Through taping applications, dorsiflexors may facilitate and help improve ankle strategy that helps restore or position the center of mass in a position that has better stability thereby increasing or expanding the stability and weight shift limits especially in the anterior-posterior direction. This is supported by a study by Karlsson and Andreasson showing improved control of ankle motion and contraction of ankle stabilizers observed after kinesiology tape applications in ankle (Karlsson and Andreasson, 1992).

The elastic taping mechanism can also be explained by the motor gamma reflex in the skin. Adhesion of tape to the skin allows continuous muscle contraction and causes muscle tone relaxation through information input on muscular contraction levels and allows for contraction and relaxation of repetitive muscles (Csapo and Alegre, 2015).

The application of elastic taping stretched from the origin to the insertion or in the direction of muscle contraction causes insertion (punctum mobile) and origin (punctum fixum) to close to the center of its mass and so are the muscle fibers, fascia and skin on it (Kumbrink, 2012). Stimulation of an area close to muscle mass will facilitate muscle movement through peripheral feedback regulation to the central nervous system resulting in increased muscle contraction and muscle relaxation of the antagonists (Haseth, 2004). Stabilizing elastic taping of the tendon will activate GTO as a mechanoreceptor located in the muscle tendon junctions in the regulation of muscle tone (Nardone and Schiepatti, 2005).

In stroke patients, elastic taping improves muscle activation through skin stimulation through modulation of sensory information resulting in reorganization at the spinal level occurring within a millisecond to several months (long-lasting reorganization), then supraspinal central stimulation results in increased kinesthetic, proprioceptive feedback, joint position sense and improve the balance of muscle activity, affect the muscle spindle and modulation of motor neurons with the end result of the reduction in muscle spindle excitability (Roy et al., 2012).

Gait speed is impaired in patients with dorsiflexor weakness as patients show gait with high steppage and circumcision to perform difficult foot clearance. When elastic taping is applied to the anterior tibialis (which is the primary dorsiflexor) and the extensor digitorum longus, this spring-assisted or functional correction technique that maintains the foot in dorsiflexion and avoids or decreases the drop foot while walking helps the patient in ground clearance. AFO is usually traditionally used to control the position of the ankle, compensate for muscle weakness, minimize abnormal gait patterns and improve walking ability. This elastic taping technique, based on its application and position, maintains ankle position so that the foot remains relatively neutral or on dorsiflexion, which helps improve normal movement and improve walking ability. By allowing foot clearance, there is a significant increase in gait speed. This is consistent with research conducted by Woo-Il Kim, Yong-Kyu Choi, Jung-Ho Lee, Young-Han Park, who studied the muscle facilitation effect using KinesioTaping on walking and stroke patient balance and concluded that the application of taping on the paresis side of the patient stroke has a positive effect on asymmetric gait improvement and walking speed (Woo-IL et al., 2014).

The observed increase in walking speeds in this study shows that elastic taping gives a positive immediate effect on walking speed can be considered as addition to the walking exercise, allowing for more effective walking rehabilitation.

Step and Stride Length Before and After Elastic Taping Application for 30 Minutes

The average step length and stride length measurements at 30 minutes after elastic taping application showed an increase compared to the baseline. A statistically significant step gain increase was found only in the step length step of the healthy side of the paresis side, which was not found in the step length of the paresis side of the healthy side. There are 2 out of 11 research subjects showing the value of all variable step length and stride length is lower than before elastic taping application although one of the subjects obtained an increase in walking speed. Two other subjects showed a paresis step length toward a lower healthy side than before the elastic taping application. Seven subjects showed consistent improvement across all the variable values of step length and stride length.

The above shows a different strategy or gait between subjects after elastic taping application. Not all subjects experience an increase in walking speed which is always followed by other gait functional components measured in this study i.e., step length and stride length. The possible compensation is to increase the cadence not measured in this study.

No other research has done taping application only on ankle dorsiflexor muscle with gait step length and stride length parameter measurement as this research. Other studies, such as those performed by Kilbreath and colleagues giving taping applications on the gluteus showed only a small increase in the healthy but not statistically significant. The study also proposed an explanation of the hypothesis of increased muscle activation through cutaneous and proprioceptive stimulation (Kilbreath et al., 2006). Son and colleagues applying kinesio taping to the gluteus medius, gluteus maximus, major psoas, anterior tibialis, and transverse abdominis on the paresis side showed improved balance associated with increased step length and stride length on the weak side (Son et al., 2008).

Clare Maguire and colleagues in the previous study showed an immediate effect of increasing step length values that were elevated compared to baseline but not statistically significant with taping intervention in the hip partial hip abductor muscle. The step length on the non-paresis side remains longer than the paresis side, just like the baseline, but the difference is reduced. An immediate improvement of the step length parameter was assessed to indicate the stimulation of the balance equilibrium with taping intervention (Maguire et al., 2010).

Improvements in all gait parameters were found in Hyun et al. This study was performed with taping application with Mulligan technique on the knee against subacute stroke subjects. Taping produces significant differences in step length and stride length as well as on cadence and gait speed. This research explains that effective taping improves dynamic balance, restores joint re-alignment and aids postural arrangements (Hyun et al., 2015).

Increased step length on the healthy side of the study can also be attributed to the transfer of skill due to unilateral input (Scripture, et al., 1894). Specifically, this skill transfer occurs after a period of unilateral training skill/stimulation mediated by the dividing mechanism. One explanation is that unilateral tasks are associated with increased excitability in both contralateral and ipsilateral motor cortical areas, termed 'cross activation'. In this model, bilateral cortical activity is generated during a unilateral training causing neural adaptation in both cerebral hemispheres as well as at the spinal level, which may have a cross-sectional effect on motor function on its contralateral side (Ruddy and Carson, 2013).

There are several limitations in this study: Short follow-up time, ie 30 minutes so that elastic taping effectiveness can not be assessed for longer duration of use on functional ability of post-stroke patient gait; All treatments and measurements are performed by the same person (not blinded) so that biases can occur; No limb length measurements were observed which might have an effect on the step length and stride length of the study subjects.

CONCLUSIONS

This study concludes that there is an increment in gait speed and step length on healthy side in post-stroke patients with ankle dorsiflexor weakness after 30 minutes of elastic taping application. Elastic taping may be beneficial in post-stroke patients ankle dorsiflexor muscle weakness, and should be used for at least 30 minutes.

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