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The Effects of Taping Prior to PNF Treatment on Lower Extremity Proprioception of Hemiplegic Patients

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Abstract. [Purpose] The purpose of this study was to compare the effects of taping on the articular angle of the knee joint and on the functioning of patients with hemiplegia resulting from stroke. [Subjects] The subjects of this study were 30 patients who were diagnosed with hemiplegia due to stroke. The subjects were randomly assigned to either an experimental group which received proprioceptive neuromuscular facilitation combination patterns and kinesio taping were applied, or a control group which received neurodevelopmental treatment. [Methods] Joint angle was measured at the hip and the ankle for both the paretic and non-paretic sides using a goniometer. Dynamic balance ability was assessed using the Berg Balance Scale. Gait velocity was measured as the 10-m walking time using a stopwatch. [Results] Comparative analysis of the experimental group's pre-test and post-test results showed statistically significant differences in the BBS and 10-m walking test. There were significant differences between the groups in ankle dorsiflexion, BBS, and 10-m walking times. [Conclusion] We judge the application of taping on the knee joint prior to rehabilitation treatment for patients in accordance with nervous system damage positively influences their functional improvement.
Key words: Stroke, Hemiplegia, Kinesio taping

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INTRODUCTION

A stroke blocks the blood supply to brain tissue due to blood flow disturbances in the vessels and triggers brain damage[1)]. About 40% of stroke patients undergo some functional damage, with 15% to 30% having severe disability[2)]. Even though many stroke patients survive through appropriate emergency care and early treatment after a stroke, they frequently suffer from motor, sensory, or cognitive disorders[3)].

Clinical aspects of patients who are hemiplegic as a result of stroke vary according to the damaged region of brain tissue, its size, and the cause of damage; and right and left asymmetry is common among them[4)]. Impaired balance resulting from such asymmetry of the body is a very frequent symptom and disrupts the activities of daily living, delays recovery of mobility, and increases the risk of falls[5)]. In general, hemiplegic patients place a load of less than 50% of their whole weight on the lower extremity on the paretic side when standing[6)]. Such abnormal weight support interrupts normal motor patterns the standing position and restricts functional movements[7)].

The incomplete gait of hemiplegic patients has been studied since the development of gait analysis methods. In particular, one appropriate method for precise analysis of gait performance, disease characteristics, and patients' compensation is the proprioceptive neuromuscular facilitation (PNF) method[8)]. PNF is known to stimulate proprioceptive receptors within muscles and tendons, thereby improving function and increasing muscle strength, flexibility, and balance[9)]. It is also effective for achieving the maximal response of motor units as it increases coordination[10)].

Kinesio taping (KT) uses elastic adhesive tape with an elasticity rate that is similar to that of the skin to treat all kinds of musculoskeletal pain and functional abnormalities. KT may either inhibit or promote muscular tension according to the application method to the relevant muscles, in order to normalize the action of moving protagonists[11, 12)]. By ultimately adjusting muscle tension when it is mixed with strong voluntary movement, balance between the protagonists, synergists, and antagonists is maintained, and physical balance is recovered[13)]. Baek et al.[14)] reported that when 10 hemiplegic stroke patients received KT applied to the muscles on the paretic side four times a week for two weeks, they showed a significant improvement in motor function on the paretic side. Kim et al.[11)] also noted that KT

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application to hemiplegic stroke patients at home resulted in significant improvements in activities of daily living, joint range of motion (ROM), and hand motions.

Accordingly, this study investigated the effects of PNF combination patterns and KT on gait ability, aiming to provide a more effective treatment method for the clinical treatment of stroke patients.

SUBJECTS AND METHODS

Subjects

The subjects of this study were 30 patients of C Hospital in Cheong-ju who were diagnosed with hemiplegia due to stroke. The subjects were randomly assigned to either an experimental group which received PNF combination patterns and KT, or a control group which received neurodevelopmental treatment. The experimental groups received three 30-minute PNF treatments per week for four weeks, a total of 12 times (Table 1).

The subjects had no visual field defects, no abnormalities in the vestibular organs after they were diagnosed with stroke, did not wear aids, and were able to understand the experimental content well enough to give their voluntary consent to participation in the experiment. The criteria for exclusion were having an artificial joint in a lower extremity, having had a previous fracture, not adopting the proper position when PNF combination patterns were applied, or having a unique skin disease.

Table 1. General characteristics of subjects (Mean ± SD)

	Experimental group (n=15)	Control group (n=15)
Age (yr)	53.4 ± 9.5	54.1 ± 8.6
Height (cm)	174.6 ± 12.6	171.3 ± 13.7
Weight (kg)	58.9 ± 7.4	59.8 ± 8.6
Gender (M / F)	8/7	7/8
Affected side (L / R)	9/6	8/7

*p<0.05

Methods

Elastic Kinesio tape was attached in the following ways.

1) Patella inferior gliding taping: The subjects lay on a bed in a supine position, and 5-cm wide Kinesio tape was cut in half with scissors and attached from the lateral surface of the proximal leg to cover the lateral superior surface of the patella across the medial surface of the patella to the medial surface of the proximal leg. 2) Patella medial gliding taping: After patella inferior gliding taping, tape was attached from the medial surface of the proximal leg to cover the lower part of the patella across the upper part of the patella to the medial surface of the distal leg. 3) Quadriceps femoris muscle taping: The subjects sat on a bed, and 5-cm wide Kinesio tape was cut into a Y-shape and attached from the tibial tubercle, the null point of the quadriceps femoris muscle across the side of the patella to the anterior inferior iliac spine, the origin of the quadriceps femoris muscle[15].

The combination patterns of PFN treatment were described by Dietz[16]. In these patterns, movement of flexion-adduction-external rotation of the paretic upper extremities and simultaneous flexion-adduction-external rotation of the non-paretic lower extremities are performed? In the present syudy, extension-abduction-internal rotation of the non-paretic upper extremities and simultaneous extension-abduction-internal rotation of the paretic lower extremities were also performed? All these integrally performed, movements are called PNF combination patterns. The subjects performed these patterns independently, but when they could not do so, the therapist aided the movement of the paretic upper extremities and encouraged the movement of the non-paretic parts with oral instruction.

In this study, PNF combination patterns were conducted with subjects in a side-lying position, half-standing position, and modified plantigrade position[17]. During the experiment, subjects' trunk alignment condition and pattern movement were checked continuously, and oral encouragement was given to the subjects to keep them in the proper position. This intervention was conducted 10 times for 10 seconds after pattern alignment was completed in each position, and 10 seconds was allowed for an interval break time. About 10 minutes was spent performing the patterns in each position.

Joint ROM was measured at the hip and the ankle for both the paretic and non-paretic sides using a goniometer with the method described by Norkin and White[18]. Dynamic balance ability was assessed using the Berg Balance Scale (BBS) which was developed by Berg et al[19]. The BBS is clinically used for patients with senile disease or hemiplegia resulting from stroke to evaluate their balance ability during movement or in a standing position. It consists of 14 items; each has a score from 0 to 4 with a maximum possible score of 56. When the score is less than 45 points, the patient needs a tool for aiding gait and has a high risk of falls.

For the ten-meter walking test, 10 m were measured on the floor using a tape measure, and tape was attached to mark the start and end points. In order to provide sufficient distance for acceleration and deceleration, four meters was added to the 10 meters marked with tape on the floor, two meters at one end and two at the other[20]. The subjects were instructed to "walk as usual at a comfortable speed." The 10 -m walking time was measured to the nearest one-hundredth of a second using a stopwatch for the time period from the moment the subjects' feet passed the starting line to the moment they crossed the finish line. The subjects practiced once, and all measurements were made three times with the average of the three being used in the analysis. For the 10-m walking test, test-retest reliability has been reported as 0.95, and inter-rater reliability as 0.90, which are very high values[21].

In the statistical analysis of this study, means and standard deviations were calculated using SPSS for Windows (version 20.0). In order to examine the effects of the intervention in each group, the paired t-test was conducted, and in order to investigate differences between the groups, the independent t-test was performed. The significance level was chosen as 0.05.

Table 2. Pre-test and post-test comparison of the experimental group (Mean ± SD)

	Experimental group (n=15)		Control group (n=15)	
	Pre-test	Post-test	Pre-test	Post-test
Hip flexion (°)	117.3 ± 12.5	121.3 ± 8.5	119.0 ± 10.3	120.5 ± 7.4
Hip extension (°)	9.3 ± 2.5	11.6 ± 1.2	9.6 ± 1.2	10.5 ± 1.3
Ankle dorsiflexion (°)	10.3 ± 5.3	12.6 ± 11.8	9.3 ± 6.2	11.2 ± 4.5
Ankle plantar flexion (°)	44.0 ± 8.0	46.0 ± 10.5	41.0 ± 7.1	43.3 ± 2.4
BBS	27.8 ± 7.9	29.4 ± 6.8*	29.1 ± 6.4	30.0 ± 5.9
10 m (sec)	40.4 ± 26.5	36.6 ± 25.9*	38.2 ± 17.2	36.8 ± 3.5*

$p<0.05$, Unit=score, BBS=Berg balance scale, 10 m=10 meter walking time

RESULTS

Comparative analysis of the experimental group's pre-test and post-test results showed statistically significant differences in the BBS and 10-m walking times ($p<0.05$). For the control group, comparative analysis of the pre-test and post-test results found a statistically significant difference only in the 10-m walking times($p<0.05$) (Table 2). There were significant differences between the groups in ankle dorsiflexion, BBS, and 10-m walking times($p<0.05$) (Table 3).

Table 3. Comparison of ROM, BBS, and 10 m gait between the groups (Mean ± SD)

	Experimental group (n=15)	Control group (n=15)
Hip flexion (°)	–1.17 ± 3.40	–2.33 ± 4.58
Hip extension (°)	–0.33 ± 1.29	–0.593 ± 1.35
Ankle dorsiflexion (°)*	–3.00 ± 4.55	–4.33 ± 11.93
Ankle plantar flexion (°)	–2.00 ± 9.96	–2.33 ± 6.78
BBS*	–1.67 ± 3.04	–0.93 ± 1.16
10 m (sec)*	2.80 ± 2.46	2.00 ± 5.78

*$p<0.05$, Unit=score, BBS=Berg balance scale, 10 m=10 meter walking time

DISCUSSION

The incidence frequency of stroke is on the rise, and in Korea it has been reported as one of the top three causes of adult death together with cancer[22]. Stroke has a high death rate, and in survivors it often causes permanent disability, despite recovery, due to functional disorders in the central nervous system. The clinical aspects differ according to the region and size of the brain tissue damaged, and the cause of the damage, but in general, asymmetric damage to the left and right sides of the body and hemiplegia occur[23].

A stoke patient typically undergoes motor and sensory function disorders according to the area and degree of brain damage; suffers from linguistic, perceptive, and cognitive damage, accompanied by emotional disorders such as anxiety, depression, agitation, and frustration; and experiences many disabilities in ordinary life[24]. Damage to the central nervous system, articular and muscular diseases, and disorders of the visual and vestibular organs affect balance performance and trigger problems with maintenance of stability in a standing position, weight load adjustment, gait ability, and functional improvement[25, 26].

Brunnstrom[27] observed hemiplegic gait and described it as slow and rigid with disharmonious adjustment motions on the affected side and compensation actions on the non-paretic side. In other words, a deficit in the motor adjustment of the central nervous system triggers unharmonious motions of the upper and lower limbs, and according to the degree of neurological recovery of the central nervous system, aspects of motor adjustment and hemiplegic gait change. As a result, patients with hemiplegia resulting from a stroke experience many disabilities in activities of daily living. Gait is a particularly basic element necesary for leading an independent life. It is considered meaningful to evaluate gait aspects and analyze related elements of gait in hemiplegic patients.

PNF applies resistance to one part of the body, indirectly triggering muscle contraction in other parts, activating them or promoting their functional activities[28, 29]. PNF uses unique spiral patterns to stimulate proprioceptors and promote normal responses. It adds stimuli to proprioceptive sensory organs, such as the muscle spindle or tendon spindle, which trigger concentric excitation in muscle length or tensile force[30]. PNF is very important for orthopedic and neurosurgical patients and essential for subjects whose central nervous system has been damaged such as stroke patients and those with motor developmental disorders including cerebral palsy syndrome[31].

PNF is very effective at increasing patients' consciousness, perception, muscle strength, coordination, and endurance by repetitively causing maximal responses, thereby improving neurological function and lowering the muscle contraction threshold, and enhancing or increasing motor ability[32]. Dietz[16] noted that simultaneous application of different patterns exerted more force, and therefore had a greater influence on muscle strength and stability. In a study that examined muscle activity in the lower extremities according to PNF combination patterns, Oh et al[33]. reported that muscle activities of the rectus femoris and the vastus medialis muscles significantly increased.

Kinesio taping is effective at correcting asymmetries in of the musculoskeletal system. The application of Kinesio tape may affect the muscle and myofascia functions. An additional theory is that KT stimulates cutaneous mechanoreceptors at the taped area, and this stimulation affects

ROM[34]. Theory states is that Kinesio tape and circulatory or neurological activation is rooted in the tape's elastic properties, which are purported to support and enhance joint functions[35].

In the present study, there were significant improvements in the BBS and 10-m walking tests of the experimental group after treatment ($p<0.05$). This result is consistent with the results of a study by Jang Ji-hoon[36], who reported that after KT was applied to the gluteus medius, gluteus maximus, tibialis anterior, and transversus abdominis muscles of the paretic side of hemiplegic patients, there were significant improvements in variables related to balance ability such as BBS ($p<0.01$), standing on the leg of the paretic side ($p<0.01$), standing on the leg of the non-paretic side ($p<0.05$), 360° rotation on the paretic side ($p<0.05$), 360° rotation of the non-paretic side ($p<0.01$), and raising the legs alternatively. Their results were due to PNF effects overlapping with the KT effects on muscle function normalization, lymph and blood circulation improvement, correction of articular misalignment, and proprioceptive enhancement.

In a study of eight hemiplegic stroke patients, Song et al.[37] reported that the 10-m walking time was 35.44 ± 14.25 seconds prior to the application of KT and significantly decreased to 29.99 ± 11.85 seconds after the application of KT. In the present study, there were differences in treatment effects between the two groups in the dorsalflexion of the ankle joints, BBS, and 10-m walking times ($p<0.05$). The experimental group saw the angle of the dorsalflexion of the ankle joints and BBS scores increase significantly, and the 10-m time decrease significantly. We consider this is because PNF combination patterns and tape application enhanced stability of the knee joints during walking and promoted muscular activity in the surrounding muscles, positively affecting functional gait.

The results of this study may not be generalized to stroke patients as a whole because the number of subjects was not sufficient; there were great differences in the disease period, age, and the gender of the subjects; and the residence of the subjects was restricted to a single area.

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