J Int Acad Phys Ther Res 2012; 3(2): 413-478
ISSN 2092-8475
www.iaptr.org
http://dx.doi.org/10.5854/JIAPTR.2012.10.30.446

Effects of Ankle Joint Taping on Postural Balance Control in Stroke Patients

This study aims to examine the effects of taping of the ankle joint on the static and dynamic balance and gait ability of stroke patients. Twenty-six stroke patients receiving physical therapy at a hospital located in Gyeonggi-do were divided equally into a group that had taping in physical therapy and an ordinary physical therapy group. They exercised for 30 minutes each, 3 times per week for 8 weeks from June to August 2011. Romberg's eye open and eye closed tests, limits of stability(LOS), forward and back test, timed up and go test(TUG) and 10-meter gait velocity test were performed to evaluate static balance, dynamic balance, and gait ability, respectively, prior to and 8 weeks after the intervention. Differences within each group in relation to the lapse of time were compared by a paired t-test. Differences between the two groups were compared by an independent t-test. Regarding comparison of differences within each group, all tests resulted in significant changes in both groups after the intervention ($p<.05$). Comparison of differences between the two groups showed that taping in the physical therapy group had significantly better test results than the ordinary physical therapy group in all measured items($p<.05$). The after effects of ankle taping on stroke patients are more efficient and effective than ordinary physical therapy alone in improving balance and gait ability.

Key words: *Static Balance; Dynamic Balance; Stroke; Gait Ability; Taping*

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Received : 21 May 2012
Accepted : 3 August 2012

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INTRODUCTION

Clinically, the primary purpose of the rehabilitation of stroke-related hemiplegic patients is the recovery of balance and gait ability(1). A general problem in the gaits of stroke patients is in ankle dorsiflexion. That is, foot drop occurs in stroke patients because the dorsiflexor is not well controlled, and the muscle tone of the triceps sura increases abnormally. These obstacles make standing and balancing difficult in the rehabilitation process of these patients, thereby preventing them from getting out of their beds and inhibiting normal gaits and activities of daily living (2). Compared to subjects with no damage to ankle joint proprioception, those with damaged ankle joint proprioception show increased body sway, lower balance scale scores(3), and larger changes in gait patterns(4).

Callaghan et al.(5) reported that taping significantly improved the accuracy of senses in those with relatively poor proprioception although it had little effect on those with excellent proprioception. Jerosch et al. (6) reported that when proprioception was examined using angle reproduction tests, errors in proprioception decreased in a group of patients with ankle damage to which taping was applied. Taping is generally known to improve proprioception and by coming into contact with the skin, provide augmented skin proprioceptor signals(7).

Therefore, the present study intends to provide experimental data on therapeutic intervention methods for improving stroke patients' independence by identifying the effects of taping on postural balance control. Taping is applied to the ankle joints, the tibialis anterior, and the gastrocnemius, which play important roles in the balance control of hemiplegic patients for physical stability when therapeutic exercises are performed, in addition to assessing stroke patients' static balance, dynamic balance, and gait ability.

METHODS

Subjects

The subjects of the present study were 26 stroke patients hospitalized in A hospital located in Gyeonggi-do. These subjects were randomly assigned to either a taping-applied therapeutic exercise group of 13 patients or a general therapeutic exercise group of 13 patients. Training was administered to both groups.

Therapeutic Exercise Program

In the present study, a therapeutic exercise program was devised by revising and supplementing the proprioception motor control program proposed by Lynch and Grisogono(8) and Peath Rohlfs(9). The therapeutic exercise program is shown in Table 1. The program was implemented in 26 patients that met the selection criteria for 30 minutes per session, three times per week for eight weeks. The same therapeutic exercise program was implemented in both the taping-applied therapeutic exercise group and the general therapeutic exercise group.

Table 1. Therapeutic exercise program

Therapeutic exercise program	Number of times and time
Stage 1: ankle joint mobility improving and muscle strengthening exercise	**20 times/10 minutes**
• Promote the range of motion of the ankle joint in a sitting position	5 times/3 minutes
• Repeat ankle joint flexion and extension	5 times/2 minutes
• Repeat ankle joint dorsiflexion and plantar flexion	10 times/5 minutes
Stage 2: weight bearing exercise in a static standing position	**20 times/10 minutes**
• Repeat the motion of moving the affected side weight in a sitting position and standing up	10 times/5 minutes
• Move the weight in diverse directions in a standing position	10 times/5 minutes
Stage 3: weight movement and task training in a standing position on one foot	**20 times/10 minutes**
• Raise the non-affected side foot in a standing position on both feet	5 times/2 minutes
• Diverse affected side weight movements in a standing position on one foot	10 times/5 minutes
• Upper extremity task training in a standing position on one foot	5 times/3 minutes

Research Tools

The therapeutic exercise program was implemented after applying Kinesio Taping(elastic taping) to the ankle joint, the tibialis anterior, and the gastrocnemius(10, 11, 12).

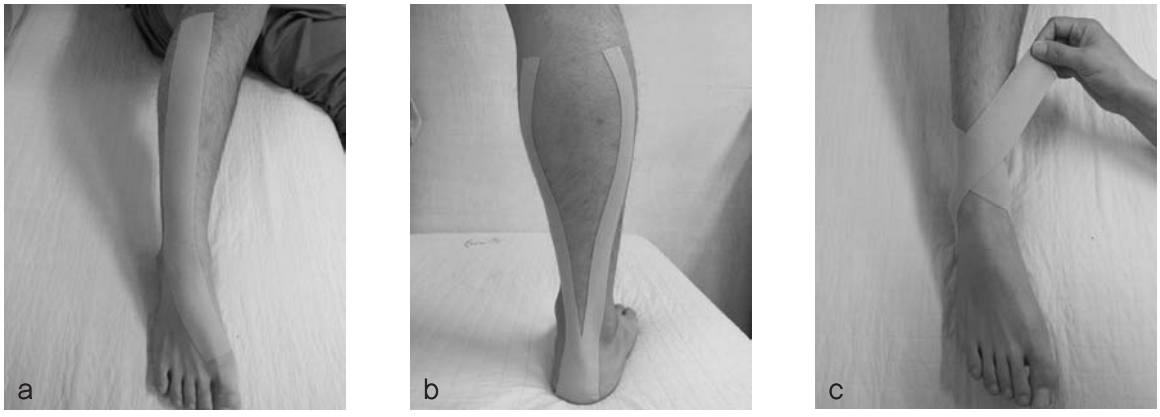

Fig. 1. Ankle joint taping
a. Tibialis anterior taping b. Gastrocnemius taping c. Ankle fig 8 taping

In the present study, a balance ability measuring and training system analysis systems by biofeedback(AP1153 Biorescue, France) was used to measure the study subjects' balance ability. Before measuring balance ability, the measuring methods were explained in detail to the subjects. In the basic measuring position, patients stood on a force plate, placing the midline of the feet on the indicated line marked at 30°, which was drawn on the force plate. In a standing position, the weight distribution areas of the left and right feet were measured after five seconds while the subject was standing on the force plate in the basic position with eyes looking straight ahead. As tests of static balance, Romberg's eyes open, eyes closed tests were conducted by measuring the movements of the center of gravity(COG) in a standing position. As tests of dynamic balance, tests of the limit of stability(LOS) and forward and back tests were conducted. The TUG test and 10m gait velocity test were used to measure gait ability. The TUG test was developed by Podsiadlo and Richardson in 1991(13), which quickly measures basic mobility and balance(14). The measurement was conducted three times in all the study subjects and average values were used as resultant values.

Research Procedure

The present study was conducted from June through August 2011, and the subjects' general characteristics were surveyed before applying therapeutic interventions to the study subjects. The therapeutic exercise program was administered to the taping-applied therapeutic exercise group with taping applied to the ankle joint, the tibialis anterior, and the gastrocnemius three times per week, 30 minutes per session. The therapeutic exercise program was administered to the therapeutic exercise group three times per week, 30 minutes per session. All assessments were conducted before the treatment and eight weeks after the treatment using the same method.

Data Analysis

All statistical analyses in the present study were conducted using PASW Statistics 18.0 for Windows. The normality of all subjects was tested using the Kolmogorov-Smironov test. The homogeneity of the subjects' general characteristics was tested by Chi-squared tests. Paired sample t-tests were conducted for intra-group comparison of each patient in the taping-applied therapeutic exercise group and in the general therapeutic exercise group at different time points during the experimental period. For inter-group comparisons, the average values of variances were calculated by deducting values obtained in pre-assessment from values obtained in assessment conducted eight weeks after the beginning of the experiment. Independent sample t-tests were conducted to compare the variances. The statistical significance level of all data was set to $\alpha = .05$.

RESULTS

General Characteristics of the Study Subjects

The results of tests of the study subjects' general characteristics and homogeneity are shown in Table 2.

Table 2. General characteristics of the study subjects

Varialbles	Group	Study group (n=13)	Control group (n=13)	X^2	p
Gender	Male	5(38%)	4(31%)	.170	ns
	Female	8(62%)	9(69%)		
Diagnosis	Cerebral infarction	9(69%)	7(54%)	.650	ns
	Cerebral hemorrhage	4(31%)	6(46%)		
Affected side	Right hemiplegia	6(46%)	5(38%)	.158	ns
	Left hemiplegia	7(54%)	8(62%)		

			F	p
Age(year)	58.85±11.26	58.77±14.46	.000	ns
Height(㎝)	160.04±7.81	160.28±6.82	.006	ns
Weight(㎏)	60.52±10.28	61.82±7.27	.140	ns
Romberg's eye open test(㎝)	32.92±10.35	38.02±11.97	1.353	ns
Romberg's eye close test(㎝)	43.57±9.15	49.45±13.94	1.619	ns
Limit of stability(㎠)	4132.20±1178.25	4209.68±1217.46	.027	ns
Fowards and back test(㎝)	51.89±11.18	57.01±11.51	1.321	ns
Timed Up and Go test(s)	24.03±6.61	27.36±6.68	1.625	ns
10 m gait velocity test(㎧)	0.68±0.24	0.55±0.22	2.125	ns

Values are N (%) or Mean ± standard deviation, ns=not significant
Study group: Applied taping and physical therapy, Control group: Physical therapy.

Comparison of Static Balance Ability before and after the Experiment in the Taping Applied Therapeutic Exercise Group and the General Therapeutic Exercise Group

The results of the comparisons of static balance ability between the two groups both before and after the experiment are shown in Table 3. In the Romberg's eye open tests, both the taping-applied therapeutic exercise group and the general therapeutic exercise group showed degreases in COG movement distances with significant differences. ($p<.05$).

Comparisons of variances in the Romberg's eye open tests showed significant differences between the two groups. The taping-applied therapeutic exercise group showed decreases by 4.18±3.03㎝ on average, and the general therapeutic exercise group showed decreases by 1.90±1.45㎝ on average($p<.05$).

In the comparison of variances in Romberg's eyes closed tests, both the taping-applied therapeutic exercise group and the therapeutic exercise group showed degreases in COG movement distances with significant differences($p<.05$). Comparisons of variances in the Romberg's eyes closed tests showed significant differences between the two groups($p<.05$).

Comparison of Dynamic Balance Ability before and after the Experiment in the Taping Applied Therapeutic Exercise Group and the General Therapeutic Exercise Group

The results of the comparisons of dynamic balance ability before and after the eight-week experiment in the taping-applied therapeutic exercise group and the general therapeutic exercise group are shown in Table 4. In tests of the limit of stability, both the taping-applied therapeutic exercise group and the therapeutic exercise group showed increased COG movement areas with significant differences($p<.05$). Comparisons of variances in the limit of stability (LOS) showed significant differences between the two groups($p<.05$).

In the forward and back test, both the taping-applied therapeutic exercise group and the general therapeutic exercise group showed decreases in COG movement distances with significant differences ($p<.05$). Comparisons of variances in the forward and back tests showed significant differences between the two groups($p<.05$).

Comparison of Gait Ability before and after the Experiment in the Taping Applied Therapeutic Exercise Group and the General Therapeutic Exercise Ggroup

The results of the comparisons of gait assessment before and after the eight-week experiment in the taping-applied therapeutic exercise group and the general therapeutic exercise group are shown in Table 5. In the TUG tests, both the taping-applied therapeutic exercise group and the therapeutic exercise group showed decreases in time before and after the experiment with significant differences($p<.05$). Comparisons of variances in the TUG tests showed significant differences between the two groups ($p<.05$). In the 10m gait velocity tests, both the taping-applied therapeutic exercise group and the therapeutic exercise group showed increases in velocity with significant differences($p<.05$). Comparisons of variances in the 10m gait velocity tests showed significant differences between the two groups($p<.05$).

Table 3. Comparison of static balance between the two groups

Varialbles	Group	Study group Mean±SD	Control group Mean±SD	t	p
Romberg's eye open test(㎝)	0 week	32.92±10.35	38.02±11.97		
	8 weeks	28.74±10.21	36.13±11.67		
	Change	4.18±3.03	1.90±1.45	-2.452	.025*
	F	18.523	23.372		
	p	.000*	.001*		
Romberg's eye close test(㎝)	0 week	43.57±9.15	49.45±13.94		
	8 weeks	35.28±9.22	48.69±13.87		
	Change	8.29±3.77	0.76±0.24	-7.185	.000*
	F	84.134	98.668		
	p	.000*	.000		

*p<.05

Table 4. Comparison of dynamic balance between the two groups

Varialbles	Group	Study group Mean±SD	Control group Mean±SD	t	p
Test of the limit of stability(㎠)	0 week	4,131.20±1,178.25	4,209.68±1,217.46		
	8 weeks	6,402.70±1,941.54	4,315.02±1,261.00		
	Change	2,270.50±957.59	105.33±81.72	8.123	.000*
	F	56.521	36.885		
	p	.000*	.000*		
Forward and back test(㎝)	0 week	51.89±11.18	57.01±11.51		
	8 weeks	43.32±12.31	56.18±11.50		
	Change	8.57±5.21	0.83±0.31	-5.341	.000*
	F	27.150	62.130		
	p	.000*	.000*		

*p<.05

Table 5. Comparison of gait ability between the two groups

Varialbles	Group	Study group Mean±SD	Control group Mean±SD	t	p
Timed Up and Go test(sec)	0 week	24.04±6.61	27.36±6.68		
	8 weeks	19.68±6.23	25.70±7.07		
	Change	4.36±3.23	1.66±1.54	-2.719	.015*
	F	20.423	89.147		
	p	.000*	.000*		
10m gait velocity test(m/s)	0 week	0.68±0.24	0.55±0.22		
	8 weeks	0.85±0.29	0.59±0.26		
	Change	0.16±0.18	0.04±0.06	2.370	.026*
	F	5.338	6.365		
	p	.024*	.015*		

*p<.05

DISCUSSION

Changes in the center of mass(COM) within the limit of stability, which is defined as the maximum distance the center of gravity(COG) can move while balance is maintained on a normal base of support, are controlled through muscles around the ankle joint. This is called ankle strategies(15). The loss of equilibrioception has been related to reduced ankle joint muscle strength(16). Sensory inputs are important for maintaining balance and integrated roles of somato sensory, visual sensory, and vestibular sensory systems. Of these, somato sensory inputs are the most important in adults for providing information about balance. Somato sensory receptors are located in joints, ligaments, muscles, and the skin. They deliver proprioceptive sensory information related to muscle length, muscle tone, and joint location(17). Previous research studied the effects of changes in the senses of the feet on plantar pressure and lower limb muscle activity. When the hind foot senses decreased, the center of pressure significantly moved toward the fore foot. The activity of the tibialis anterior decreased and the activity of the medial gastrocnemius increased. When the fore foot senses decreased, the center of pressure significantly moved toward the hind foot, the activity of the medial gastrocnemius decreased, and the activity of the hamstring increased(18). It can be inferred from the aforementioned studies that the activity of the tibialis anterior and the medial gastrocnemius serve important roles in recovering the COM to a stable position by concentrating body movements on regions around the ankle joint in ankle strategies. To measure body sway, the movements of the center of pressure and the COM are generally measured(19). Silsupadol et al.(20) reported that the measurement of the center of pressure could be a measurement tool sensitive to balance.

In the present study, static balance ability was measured. The results of comparisons between the groups were as follows: the taping-applied therapeutic exercise group showed decreased average movement distances compared to the general therapeutic exercise group with significant differences. In the case of dynamic balance ability, the taping applied-therapeutic exercise group showed increased average movement areas compared to the general therapeutic exercise group with significant differences. These results are consistent with the results of previous studies(21, 22), indicating that taping positively affected posture control ability by limiting excessive movements of joints and providing somato sensory feedback(21, 22). The increased static posture sway in hemiplegic patients is considered the result of decline in balance ability, which is caused by decline in the proprioception of the ankle joint or in the function to distribute weight appropriately while motions are performed. Therefore, the results of the present study showed that therapeutic exercise with the application of ankle-joint taping improved proprioception and weight distribution functions to enhance balance ability.

In the present study, in order to measure gait ability, gait velocity was measured using the TUG tests and 10m gait velocity tests. Comparisons between the groups showed that the taping-applied therapeutic exercise group had decreased average time and increased average velocity with significant differences. In relation to sense of balance, ankle joint taping reduced the time it took to recruit the dynamic ankle joint stabilizer muscles by limiting excessive joint movements and improving proprioceptic feedback mechanisms(23). The application of ankle joint taping increases proprioception senses when no weight is applied so that joint locations in plantar flexion can be more clearly recognized and balance ability can be improved(24). In alignment with previous studies, the present study showed that the application of taping improved gait ability by improving proprioceptic feedback mechanisms, thereby reducing the time needed to recruit the dynamic ankle joint stabilizer muscles.

The results showed that ankle joint taping increased stroke patients' proprioception and thus was effective in improving balance ability and gait ability. Therefore, ankle-joint taping is considered helpful in the clinical recovery of stroke patients' functions. However, further studies are necessary to determine whether the application of taping has lasting effects through long-term follow-ups. These studies should be conducted with larger numbers of patients in order to generalize the results.

CONCLUSION

The present study examined the effects of ankle-joint taping on therapeutic exercise regarding stroke patients' static balance ability, dynamic balance ability and gait ability. A taping-applied therapeutic exercise group and a general therapeutic exercise group were administered therapeutic exercise programs for 30 minutes per session, three times per

week for eight weeks. According to the results, therapeutic exercise with the application of ankle-joint taping increased proprioception and thus was effective in improving the static balance, dynamic balance, and gait abilities of stroke patients in this group.

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