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Original Article

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Effect of Neuro Dynamic Technique and Instrument Assisted Soft Tissue Mobilization on Lower Extremity Muscle Tone, Stiffness, Static Balance in Stroke Patients

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Purpose: This study was undertaken to compare the efficacy of instrument assisted soft tissue mobilization (IASTM) and a neural dynamic technique (NDYT). As an intervention to treat spastic lower limb muscle tone, stiffness, and static balance in stroke patients.
Methods: Totally, 26 participants were assigned randomly to two groups: the IASTM (n = 13) and NDYT (n = 13) groups. Both groups were subjected to their respective technique for 15 minutes, 5 times a week, for 6 weeks. Muscle tone, stiffness, and static balance were evaluated before and after training, to compare both group changes.
Results: IASTM group showed significant decrease in the gastrocnemius medial region and semitendinosus muscle tone and stiffness ($p < 0.05$) compare to NDYT group; however, no significant different was observed in static balance between groups ($p > 0.05$).
Conclusion: The results suggest that IASTM is an effective method for decreasing the muscle tone and stiffness in acute stroke patients.

Keywords: Balance, IASTM, Muscle tone, Neural dynamic technique, Stiffness

INTRODUCTION

Stroke is a cerebrovascular disease resulting from abrupt blockage or rupture of the blood vessel supplying blood to the brain.[1] Most stroke patients present with a one-sided paralysis of the body, along with loss of balance due to decreased motor and cognitive functions and damaged sensation, thereby increasing the risk of falls and decreased activity in daily living.[2,3]

Spasticity is one of the symptoms of upper motor neuron syndrome, showing increased muscle tone in proportion and dependent on contraction speed, with the hyperexcitability of stretch reflex. It is a form of dystonia, and the spastic co-contraction of agonist and antagonist is due to occurrence of the lesion on the descending tract of the corticospinal tract.[4-6] The symptoms appear days or weeks after the occurrence of a stroke. Spasticity is a common syndrome appearing in over 30% of stroke patients,[7] causing pain, ankylosis, tendon retraction, and muscle weakening in stroke patients, and affecting the voluntary motion, intervention, and balancing ability of muscles.[8,9] Thus, spasticity is responsible for limiting the successful rehabilitation, and exerts a harmful effect on the daily life and reduces the quality of life. Hence, spasticity needs to be managed for improving the life of stroke patients.[10,11]

A conservative method to treat spasticity is physical therapy intervention, which comprises using physical modalities, including electrical therapy applied directly as transcutaneous electrical nerve stimulation to the spastic areas, or applying it to the dermatome in the corresponding nerve.[12] Other interventions include applying local vibration stimulation to the local region for somatosensory stimulation, inducing the release of tightness by applying ice, application of heat intervention before the reduce anxiety of the subject and stretching of the tensed area, and the stretching method to increase soft tissues elasticity like muscle, tendon, and ligament in the areas of spasticity.[13-15] Of these, neural dynamic technique (NDYT) is the technique that reduces tension of the neural tissue with the neural sliding phenomenon, and eases the flow of blood supply through the nerve, to help in recovery of the nerve and soft tissue. This therapeutic technique reduces the dynamic sensitivity of the neural tissue,

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and enhances the tissue compliance for alleviating the symptoms.[16,17] The instrument assisted soft tissue mobilization (IASTM) method relaxes the fascia, connective tissue, and tightened tissues for recovering movement of the corresponding muscle; the applied principle involves triggering a partial inflammatory response to the region to resynthesize blood, fiber glia, and collagen, and to reduce tension of the muscular tissue for helping functional movement with increased flexibly and efficiency.[18,19]

In a previous study that used NDYT as an intervention, Villafañe et al.[20] applied botulinum toxin and NDYT for a patient having moderate spasticity of the upper extremity. They reported significant changes in the modified Ashworth measure, pain score, and joint motion range. Castilho et al.[21] stated that on an average, muscle activation reduced 17% when measured for muscle activation of the biceps brachii, after executing the neural dynamic technique in 6 stroke patients.

In precedent studies applying IASTM, Cheatham et al.[22] reported increased threshold of pressure pain and sensory perception ability of the local region after applying Assisted Soft Tissue Mobilization for the region having delayed onset muscle soreness subsequent to exercising in healthy adults. Looney et al.[23] reported decreased pain and improved motion performance in daily life, after application of IASTM in a patient having pain with plantar fasciitis. In studies that applied IASTM for neurological patients, Miller et al.[24] reported increased range of ankle motion and improved motion performance in daily life in a child afflicted with cerebral palsy for more than 6 months. In subjects with spasticity, Lee et al.[25] subjected the gastrocnemius to IASTM, to study the immediate effect on the reciprocal inhibition and innervation. They reported decreased muscle activation of the gastrocnemius, and increased muscle activation of the tibialis anterior. However, to date, there are few studies applying IASTM to stroke patients, and researching the direct comparison with other intervention techniques is also insufficient. Hence, we undertook to compare the effect on muscle tone, stiffness, and balance of the spastic region after exposure to IASTM and NDYT in subjects having hemiplegia due to stroke. We hypothesized that mechanical properties with over tension will decrease and balance will increase after intervention by both methods, and there will be a difference in outcome in comparison of the two methods.

METHODS

1. Subjects

Totally, 26 stroke patients hospitalized at the G hospital located in Daegu Metropolitan City. All subjects were fully informed about the study objectives and methods prior to the experiment and voluntary consent was received from each participant. Gender, age, weight, height, onset date, and spasticity of all subjects were assessed before the experiment, and subjects were randomly assigned to two groups. Inclusions for selecting a research subject were as follows: onset period of 6 or less months after being diagnosed as hemiplegia due to stroke, having scored 24 or more points of the Korean Mini Mental State Examination (K-MMSE), understanding and performing the details directed by the researcher. a patient who can stand on his own self for more than five minutes, spasticity level of 1 to 3 points as determined by the modified Ashworth scale (maximum 4 points). Patients who were treated injection for spasticity whithin the last 1 month, a patient with bruises or open wounds to the lower extremities, were excluded from the study. No significant differences in homogeneity and normality tests were found between the groups ($p > 0.05$)(Table 1).

2. Procedure

The experiment was conducted for 6 weeks. We assessed mechanical properties of paretic lower limbs, static balance ability. The 26 subjects selected were divided into two groups: instrument assisted soft tissue mobilization (IASTM) group and neural dynamic technic (NDYT) group according to the intervention method. All subjects underwent general physical therapy 5 times a week for 30 minutes per section. Additionally, the IASTM group treated 5 times a week for 15 minutes per section. The NDYT group underwent the intervention 5 times a week for 15 minutes per section.

3. Experimental methods

1) Neural dynamic technique

This study applied the neural dynamic tensioner technique of extending

Table 1. General characteristics of the subjects

Variables	IASTM (n=13)	NDYT (n=13)	t	p
Gender (M/F)				
M	7 (54%)	8 (61%)		
F	6 (46%)	5 (39%)		
Age (yr)	66.0±8.4†	63.5±8.5	0.74	0.465
Weight (kg)	62.8±10.1	69.3±9.4	-1.70	0.101
Height (cm)	163.9±9.1	168.9±9.1	-1.40	0.174
MAS (score)	1.2±0.4	1.1±0.3	1.06	0.296
MMSE-K (score)	24.9±1.0	25.8±2.3	-1.31	0.200
Stroke onset (m)	2.5±1.6	2.9±1.4	-0.65	0.520

†mean±standard deviation (SD).
MAS: Modified Ashworth Scale, MMSE-K: Mini Mental State Examination-Korean version, IASTM: Instrumental Assisted Soft tissue Mobilization, NDYT: Neural Dynamic Technique.

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Figure 1. Neurodynamic Technique.

Figure 2. Instrumented Assisted Soft Tissue Mobilization.

the total nerve length for tension application.[26] Sciatic nerve dynamic technique, repetitive cervical flexion, followed by hip joint adduction and internal rotation in the Straight Leg Raise (SLR) position with ankle dorsiflexion, was performed in the supine position. In case of femoral nerve dynamic technique, the therapist maintained hip extension, knee flexion, and ankle plantar flexion on the paralytic side with cervical vertebrae extension, and hip and knee joints of flexion on nonparalytic side, with patient lying on his side. Intervention was done for a total of 15 minutes each cycle being: sciatic nerve (7 min), rest (1 min), femoral nerve (7 min)(Figure 1).

2) Instrument assisted soft tissue mobilization

The method of Laudner et al.[27] was partially modified and applied to Instrument Assisted Soft Tissue Mobilization, using the Bodywork detector (Bodywork technique, Pangyo, South Korea). For application to the semitendinosus, IASTM was applied from the gluteal line to the popliteal region, with subject lying prone position on the mat having knee bent at 60° and the paralytic side ankle resting on the chest of the therapist to facilitate comfortance. For application to the gastrocnemius medial region, IASTM was applied from the popliteal region to the calcaneus of the Achilles tendon by changing the knee posture from position to bending at 45°. For application to the tibialis anterior, IASTM was applied from upper part of the tibia and interosseous membrane to the part contacting lateral malleolus, after bending the knee at 45° in the supine position. Stroking was applied to the bone interosseous membrane using rear end of the tool. Stroking was applied from the cranial direction to the causal direction, with the tool at 45° incline and during intervention applied massage cream, according to the technique application guidelines. In order to control the strength and quantity of mechanical stimulation constantly, the metronome was used and applied to each part 40 BPM. It was applied to each part for 5 minutes and applied for a total of 15 minutes (Figure 2).

3) Measurement of paralytic side mechanical properties

In order to maintain muscle tone and stiffness of the subject in the stable state, all measurements were done on the weekend when there was no treatment schedule. It was done in an independent place with no noise. The room temperature was maintained at 20-24°C, and humidity at 50-60%. MyotonPRO (Myoton AS, Tallinn, Estonia) was used to measure the spasticity of the subject, and the tibialis anterior, the semitendinosus, and the gastrocnemius medial region were measured in the afflicted region, with the measurement taken in the central region of the belly of each muscle.[28] The appropriate location was first indicated with a marker before commencing the measurement, and the average value was used after obtaining three measurements, according to the protocol suggested by the manufacturer. The reliability within the rater having the equipment applied to the biceps brachii of the stroke patient was determined to be ICC 0.86-0.96, indicating high reliability of the equipment.[29]

4) Balance ability measurement

To measure the balancing stability of standstill subjects, the balance ability measurement software (Balancia software, Mintosys, Korea) was used on the basis of the Wii Balance Board, which was connected to the computer through Bluetooth. Measurements were achieved by collecting the pressure center information in real time through the 4 road cells. The collected pressure center data was analyzed through the Balancia software. The variables used in the research were the sway speed average, sway distance average, and 95% sway area average.

The measurements were performed in a comfortable standing position,

after taking off shoes and standing on the pressure pad. The average value of three repetitive measurements was used, each measurement done for one minute. In order to prevent the subject from falling during measurement, the therapist provided close assistance. The pre-practice was conducted and measured to exclude learing effects. Reliability between the raters for the measurement of static balance ability of the Balancia software for stroke patients is 0.79-0.96, with the validity of 0.85-0.96 indicating high reliability and validity.[30]

4. Statistical analysis

Statistical analysis of the data collected was done using the SPSS for Windows ver. 25.0. (IBM Co. Armonk, NY, USA). The average and the standard deviation of the general characteristics of the subjects were found with the normality verification by applying Shapiro-Wilks. We used the paired t-test to respectively verify the difference between pre-and post-test mean values within the group. Independent t test was performed to compare the differences in variation between the groups, the statistical significance level α was set to 0.05.

RESULTS

1. General characteristics of subjects

All subjects answered the questionnaires to determine general characteristics of gender, height, weight, and outbreak period. Finally, 26 subjects participated in the research. The general characteristics of the two groups are presented in Table 1.

2. Difference in muscle tone and stiffness between groups

Table 2 shows difference in muscle tone and stiffness between groups. In tibialis anterior, there was no significant difference between groups ($p > 0.05$), gastrocnemius medial region muscle tone was significant difference between groups. But, stiffness was no significant difference between groups. Semitendinosus shows significant difference between groups in both muscle tone and stiffness ($p < 0.05$).

3. Difference in static balance ability between groups

Table 3 shows difference in static balance ability between groups. In static balance ability, there was no significant difference between groups in any items ($p > 0.05$).

DISCUSSION

Our results indicate that mechanical properties of gastrocnemius medial region and semitendinosus showed significant difference in the IASTM group, as compared to the NDYT group ($p < 0.05$). But, in tibialis anterior, there was no significant difference between groups ($p > 0.05$). Also, static balance ability showed no significant difference between two groups ($p > 0.05$).

Table 2. Comparison of muscle tone and stiffness according to each group

		IASTM group (n=13)		NDYT group (n=13)		t	p
		pre	post	pre	post		
TA	Tone (Hz)	19.63±3.54†	18.24±3.72	19.61±2.06	18.76±2.96	0.054	0.585
	Stiffness (N)	356.23±64.01	338.53±59.62	310.61±50.35	309.61±55.59	1.563	0.131
GM	Tone (Hz)	14.02±2.76	14.22±1.86	16.82±3.38	15.12±2.43	-2.266	0.033*
	Stiffness (N)	272.30±38.91	270.53±28.81	281.92±44.64	267.23±32.79	-1.560	0.132
ST	Tone (Hz)	15.66±2.57	13.93±1.21	15.72±2.16	15.90±2.50	2.856	0.009*
	Stiffness (N)	295.07±45.38	263.69±29.67	272.38±20.88	277.53±31.89	3.992	0.001*

†mean±standard deviation(SD).
IASTM: Instrumental Assisted Soft Tissue Mobilization, NDYT: Neural dynamic Technique, TA: tibialis anterior, GM: gastrocnemius medial region, ST: semitendinosus. *$p < 0.05$.

Table 3. Comparison of static balance ability according to each group

	IASTM group (n=13)		NDYT group (n=13)		t	p
	Pre	Post	Pre	Post		
Velocity average (cm/s)	3.52±0.56†	3.16±0.31	3.51±0.66	3.43±0.28	0.825	0.585
Path length (cm)	49.14±5.07	46.17±4.23	49.01±5.35	46.23±3.30	0.123	0.903
Path velocity (cm^2)	3.78±0.63	3.35±0.23	3.85±0.55	3.51±0.30	0.352	0.728

†mean±standard deviation (SD).
IASTM: Instrumental Assisted Soft tissue Mobilization, NDYT: Neural Dynamic Technique.

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In this study shows significant difference between IASTM group with NDYT group in gastrocnemius medial region and semitendinosus. Markovic[31] explained that joint motion range and muscle tone were decreased IASTM group when compared to the group receiving static stretching, in juvenile soccer players. They reasoned that increasing temperature of the corresponding local region during application of stroking results in increased sliding of the fascia layer, and decreased collagen resistance. Our study determined that the IASTM group generated decreased muscle tone in comparison with the NDYT group, thereby supporting findings of the preceding research. Furthermore, according to Schleip[32], muscle tone is lowered since the IASTM activates the mechanoreceptor of the inner layer of fascia and converts it into proprioceptive stimulation to affect the central nervous system. According to Simatou et al.[33] IASTM uses the narrow surface area so that deeper penetration into the target is performed, with stimulation strength of the mechanoreceptor being different from that of another intervention method, which is similar to findings in our study.

In our study, there was no significant difference in mechanical properties of tibialis anterior. Lee et al.[34] demonstrated that foot stiffness like claw foot in stroke patients, decreases function and balance ability of the lower extremity muscles. Parts of this study results, tibialis anterior muscular insertion site is located in medial cuneiform born and 1st metatarsal, plantar fasciae is located nearby. So, they reported there was strong links between higher tensions of plantar fasciae with increases tension of tibialis anterior. But, our study was not performed IASTM on the foot region. Whereas, in NDYT group, SLR (straight leg raise) with dorsiflexion was performed manually from the therapist, this position facilitated length of the plantar fascia.[35] For this reason, there was no significant difference between groups in mechanical properties of tibialis anterior.

In our study, there was no significant difference in balance ability between groups. Balance is defined as the ability to maintain the body in equilibrium, and maintain the center of mass within an unstable surface. Balance requires proper interaction of joint mobility, sensory system, central nervous system, and musculoskeletal system.[36,37] In this context, to improve balance ability, the mechanical properties of the muscles are important, but it is also very important to train other element of balance together, like a proprioceptive sensation and muscle strength. However, in this study was conducted simply by focusing on the mechanical characteristics of the muscles, other factors that might affect the balance ability were excluded, and it seems that there was no difference in balance ability between the two groups. Therefore, future research will need to investigate the difference between the two methods by performing other interventions related to balance ability.

In our study have some limitations. First, the number of subjects is not large (13 subjects per group); hence, it is difficult to generalize the results to all stroke patients. Second, as there is no agreement on the application period and strength of IASTM, it is difficult to prepare a standard for the comparison with another intervention technique. Therefore, further research on comparing the effect with another intervention technique should be done by including more subjects with the limitations supplemented, and by preparing the standards of proper application period and strength of the IASTM. Third, in mechanical properties of gastrocnemius medial region, there was significant difference in muscle tone but no significant difference in stiffness between groups. Our study could not explained this outcomes

The current study endeavored to compare effects of two therapeutic methods (IASTM and NDYT) on the muscle tone, stiffness, and static balance ability of lower extremity in acute stroke patients. Spasticity develops as a result of CNS injury, leading cause of secondary changes within the muscles and connective tissues also contribute to muscle tension and stiffness, our results suggest that IASTM is appropriate intervention method with no adverse effect used in stroke patients. And also, in the study has no significant difference in balance between groups, but if think that appropriate combination of both therapeutic methods is considered help to prevent a change in the mechanical properties due to spasticity.

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