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Comparison of Ultrasonographic Architectural Properties and Balance Ability Based on the Muscle Contraction of Chronic Stroke Patients

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Abstract. The purpose of this study is to compare the ultrasonographic architectural properties of muscles and balance ability based on the muscle contraction of chronic stroke patients. The subjects of this study were 30 chronic stroke patients were divided into 3 classes based on the Modified Ashworth Scale (MAS), with 10 patients in each class. Ultrasonographic architectural properties and balance ability were measured using ultrasonographic and a balance measurement system, respectively. According to the study result, as the spasticity level increased, the muscle thickness, pennation angle, and fascicle length significantly decreased ($p<.001$), whereas the sway area, sway path, and sway average speed significantly increased ($p<.001$), based on each condition. This study presented that pathokinesiological characteristics of the medial gastrocnemius muscle should be taken into account in chronic stroke patients balance training.

Keywords: Ultrasonographic architectural properties, Balance Ability, Spasticity

1 Introduction

Ankle joint spasticity, which is the most frequent symptom of stroke patients, is a major obstacle to the treatment of stroke patients [1]. Gao et al.[2] reported ultrasonographic properties of the medial gastrocnemius muscle at the positions of muscle fibers and ankles in stroke patients. Previous study showed that a change in the structural properties of a skeletal muscle occurs during a voluntary contraction and an isometric contraction [3]. In the meantime, stroke patient because inappropriate postural control influences the musculoskeletal functions, a structural change in a skeletal muscle is often found on the paretic side [4]. This study attempted to present that pathokinesiological properties of the medial gastrocnemius muscle should be taken into account in chronic stroke patients balance training.

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2 Subject and methods

2.1 Subjects

The subjects of this study comprised 30 chronic stroke patients who were evaluated with reference to the Modified Ashworth Scale (MAS) [5] and were classified into 3 MAS classes, with 10 subjects in each class. The medical conditions of the subjects were as follows: those who had undergone the onset of stroke 6 months to 2 years ago, those whose ankle joint MAS class was between 1 to 3 (those whose MAS class was 0 were excluded from the study), those who had no pathologic finding in the musculoskeletal system at the joint ankle, those who could walk 10 m or longer independently without the physical help of another person while wearing an ankle foot orthosis, and those who could understand the directions of the researcher and accordingly perform activities. The clinical characteristics of the subjects are shown in Table 1.

Table 1. Clinical characteristics of the subjects

Characteristics	MAS G1 (n=10)	MAS G2 (n=10)	MAS G3 (n=10)
Gender(Male/Female)	5/5	4/6	5/5
Affected side(Left/Right)	5/5	4/6	5/5
Causes(Ischemic/Hemorrhage)	4/6	6/4	5/5
Since onset(Month)	16.60±3.30	18.40±2.01	18.30±1.15
Height(㎝)	164.10±5.97	165.50±7.64	164.40±7.66
Weight(㎏)	62.40±8.69	62.90±9.49	62.00±8.60
Age(Year)	65.40±6.34	66.10±4.45	65.60±4.29

Value are given as mean±standard deviation

2.2 Methods

Ultrasonographic measurement. The medial gastrocnemius muscle was measured using ultrasonographic (GE LOGIQ 3 EXPERT Color Doppler Ultrasound System: GE Medical System Co., Korea). We employed a 12 ㎒ linear transducer whose gain (G72) and dynamic range (C4) were fixed and applied to all the tests. The muscle thickness (㎜) determined by measuring the vertical distance between the superficial part and the deep aponeurosis, so that the aponeurosis could be excluded. The pennation angle (°) was measured as the angle of the fascicle connected with the deep aponeurosis. The central part of the muscle belly, which is approximately 30% proximal point from the center of an ankle joint, was measured in the longitudinal direction [6].

Balance ability. Balance ability was measured using Biorescue(RM Ingenierie Co., France), which is a measurement system for measuring balance ability. The static balance ability was determined by measuring the sway area (㎟) and sway path (㎜). The dynamic balance ability was determined by measuring the sway average speed (㎜/s) [7].

2.3 Statistical Analysis

For statistical analysis, SPSS 12.0 for Windows was used. A paired t-test was performed with respect to the difference in the ultrasonographic architectural properties based on the muscle contraction. A one-way ANOVA was performed with respect to the difference in the ultrasonographic architectural properties and the balance ability among the groups. A Scheffe multiple range test was performed as a post-hoc test. The statistical significance level was set at α=.05.

3 Results

3.1 Differences in the ultrasonographic architectural properties and balance ability among the groups and within each group

As the spasticity was increased, the muscle thickness, pennation angle, and fascicle length during rest and during MVIC significantly decreased in each group (p<.001). The sway area, sway path, and sway average speed significantly increased during MVIC in each group (p<.001). The pennation angle was significantly greater during MVIC than during rest in each group (p<.001). The muscle thickness and fascicle length were significantly smaller during MVIC than during rest in each group (p<.001) (Tables 2 and 3).

Table 2. Differences in the ultrasonographic architectural properties of the medial gastrocnemius muscle on the paretic side among the groups and within each group

	State	MAS G1 (n=10)	MAS G2 (n=10)	MAS G3 (n=10)
Muscle Thickness(㎜)	Rest###	10.67±1.44	8.58±0.80	6.31±0.40
	MVIC###	9.36±1.33***	7.12±0.65***	5.27±0.50***
Pennation Angle(°)	Rest###	21.55±1.89	19.18±0.90	16.09±0.74
	MVIC###	25.26±1.50***	22.16±0.98***	18.25±1.35***
Fascicle Length(㎜)	Rest###	27.53±0.80	25.18±0.91	22.70±0.51
	MVIC###	26.03±0.84***	23.41±1.29***	20.81±0.48***

Value are given as mean±standard deviation
A paired t-test was performed with respect to the difference in the ultrasonographic architectural properties based on MVIC (***: p<.001; **: p<.01; *: p<.05).
A one-way ANOVA was performed with respect to the differences in the ultrasonographic architectural properties among the groups. A Scheffe multiple range test was performed as a post-hoc test (###: p<.001; ##: p<.01; #: p<.05).
MVIC : Maximum Voluntary Isometric Contraction

Table 3. Difference in the balance ability among the groups

	State	MAS G1 (n=10)	MAS G2 (n=10)	MAS G3 (n=10)
Sway Area(㎟)	Contraction###	201.00±23.09	308.70±27.74	419.50±33.04

Sway Path(㎜)	Contraction###	221.90±28.75	308.80±23.91	392.20±32.46
Sway Average Speed(㎜/s)	Contraction###	208.50±24.35	276.30±33.04	369.70±43.30

Value are given as mean±standard deviation
A one-way ANOVA was performed with respect to the differences in the balance ability among the groups.
A Scheffe multiple range test was performed as a post-hoc test (###: p<.001; ##: p<.01; #: p<.05).

4 Discussion

Maganaris et al.[7] reported that the structural properties of the skeletal muscle were significantly altered during MVIC. These previous study suggest that the weakening of the skeletal muscle on the paretic side is highly correlated with spasticity and contracture [8]. The results of the present study showed that the pennation angle was significantly greater (p<.001) and the muscle thickness and fascicle length were significantly smaller (p<.001) during MVIC than during rest in each group. This result is consistent with the results of the previous studies, indicating that the structural properties of skeletal muscles change based on the muscle contraction.

The balance ability of stroke patients decreases owing to weakened muscle strength as the ultrasonographic architectural properties decrease in the lower limb skeletal muscle [9]. The result of this study showed that as the spasticity increased, the sway area, sway path, and sway average speed during MVIC significantly increased in each group (p<.001). This result suggests that the change in the ultrasonographic architectural properties of the skeletal muscle on the paretic side might negatively influence balance ability. In other words, the change in the structural properties of the skeletal muscle on the paretic side might affect stroke patients' balance ability and result in decreased active motion and weakened muscle strength, eventually interrupting standing up or gait.

In other words, the results provided pathokinesiologic information about the medial gastrocnemius muscle, suggesting that the information be considered in balance training.

References

1. Bohannon, R.W., Larkin, P.A., Smith, M.B., Horton, M.G.: Relationship between static muscle strength deficits and spasticity in stroke patients with hemiparesis. Phys. Ther. 67(7), 1068--1071 (1987)
2. Gao. F., Grant, T.H., Roth, E.J., Zhang, L. Q.: Change in passive mechanical properties of the gastrocnemius muscle at the muscle fascicle and joint levels in stroke survivors. Arch. Phys. Med. Rehabil. 90(5), 819--826 (2009)
3. Arampatzis, A., Karamanidis, K., Stafilidis, S., Morey-Klapsing, G., DeMonte, G., Brűqqemann, G. P.: Effect of different ankle- and knee-joint positions on gastrocnemius medialis fascicle length and EMG activity during isometric plantar flexion. J. Biomech. 39(10), 1891--1902 (2006)
4. Li, L., Tong, K.Y., Hu, X.: The effect of poststroke impairments on brachialis muscle architecture as measured by ultrasound. Arch. Phys. Med. Rehabil. 88(2), 243--250 (2007)

5. Bohannon, R.W., Smith, M.B.: Interrater reliability of a modified Ashworth scale of muscle spasticity. Phys. Ther. 67(2):206--207 (1987)
6. Tatsuya, K.Y., Masaaki, S.M., Kazuo, K.T.: Comparing changes in the calf muscle during weight-bearing and non-weight-bearing stretching. J. Phys. Ther. Sci. 23(3), 395--399 (2011)
7. Maganaris, C.N., Baltzopoulos, V., Sargeant, A.J.: In vivo measurement of the triceps surae complex architecture in man: implications for muscle function. J. Physiol. 512(Pt 2), 603--614 (1998)
8. Patten, C., Lexell, J., and Brown, H. E.: Weakness and strength training in persons with poststroke hemiplegia: rationale, method, and efficacy. J. Rehbil. Res. Dev. 41(3A), 293--312 (2004)
9. Enoka, R.M.: Muscle strength and its development. New perspectives. Sports. Med. 6(3), 146--168 (1988)