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The Correlation between Abdominal Muscle Thickness and Postural Balance in Chronic Stroke Patients

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Objective
To evaluate the correlation between postural balance and asymmetry of abdominal muscle thickness in both resting and activation state in chronic stroke patients.

Method
The 24 chronic hemiplegic stoke patients were included in this study, who were diagnosed with brain hemorrhage or infarction by radiologic evaluation. We included (1)patients whose post-onset duration is more than 6 months, (2)patients who have ability to follow instruction for abdominal muscle activation(K-MMSE≥15), (3)patients who have ability to follow instruction for evaluation of balance tests. And we excluded (1)patients who have quadriplegic or double hemiplegic impairment, (2)patients who have history of spine or disc related operation and scoliosis, (3)patients who have more than 27 of body mass index(BMI), (4)patients who have ataxic movement. We evaluated the parameters of postural balance by measuring the trunk impairment scale(TIS) and berg balance scale(BBS). And we measured the total abdominal muscle thickness(summation of external oblique, internal oblique and transverse abdominis muscles) by ultrasound in both resting and activation state. Partial correlation coefficient was used to analyze the correlation between abdominal muscle thickness and postural balance. And Mann-whitney U test was used to analyze the differences of subgroups in patients. Data analyses involved use of SPSS v18.0 for Windows. P value < 0.05 was considered statistically significant.

Results
Demographic information of the enrolled chronic stroke patients is presented in Table 1. The abdominal muscle thickness of paretic side in both resting and activation state was correlated with BBS($r= 0.57$, $r=0.67$, $p<0.05$). Also, the contraction ratio of the paretic side abdominal muscle was significantly correlated with the TIS($r= 0.61$, $p<0.05$)(Table2). We found that the two types of the asymmetry of the abdominal muscle thickness. The abdominal muscle of non-paretic side was thicker (159.6mm ± 36.1 vs 133.7mm ± 30.0) than paretic side in 12 patients(NTG). However, in the other 12 hemiplegic patients(PTG), abdominal muscle of paretic side was thicker(140.0mm ± 20.0 vs 125.2mm ± 18.1)(Table 1). The spasticity of the PTG was significantly higher than the NTG($p<0.05$). In the NTG, bilateral abdominal muscle thickness became less asymmetric during activation and TIS score was significantly higher than the PTG(Table 3).

Conclusion
This study demonstrated that the abdominal muscle thickness and contraction ratio of paretic side were correlated with trunk balance in the chronic stroke survivors. In

addition, the NTG had a better dynamic sitting balance than the PTG. Although spasticity had affected the abdominal muscle thickness of paretic side, it didn't mean good contractility or strength. Therefore, the ability of fascilitation of paretic side abdominal muscle might be important to dynamic sitting balance in the chronic stroke survivors.

Table1. Patients' demographics and clinical characteristics

Characterists	Subjects(n=24)	NTG(n=12)	PTG(n=12)
Sex			
Male : Female	19 : 5	8 : 4	11 : 1
Age(years)	61.0±12.5	59.3±15.9	62.8±8.1
Post-onset duration(months)	53.8±42.5	52.75±42.0	54.8±44.9
Lesion Type			
Hemorrhage : Infarction	17 : 7	10 : 2	7 : 5
Lesion Side			
Right : Left	12 : 12	4 : 8	8 : 4
K-MMSE	26.6±3	26.7±3.1	26.4±3.1
BMI	23.0±2.4	23.0±2.9	22.9±2.0
BSA(m^2)	1.7±0.2	1.7±0.2	1.7±0.1
Absolute thickness of abdominal muscle (mm)			
Resting			
Paretic side	136.8±25.0	133.7±30.0	140.0±20.0
Non-paretic side	142.4±33.0	159.6±36.1	125.2±18.1
Activation			
Paretic side	227.3±43.6	232.8±54.3	222.0±31.1
Non-paretic side	233.5±57.6	257.5±53.5	209.4±53.0

Values are presented as n:n or mean±standard deviation
NTG: non-paretic side thicker group in resting abdominal muscle thickness, PTG: paretic side thicker group in resting abdominal muscle thickness, K-MMSE: Korean Mini-Mental State Examination, BMI: body mass index, BSA: body surface area

Table 2. Partial correlation between abdominal muscle and postural balance adjusted by sex, age, height, weight, BMI and BSA

	TIS	BBS
Variables	Correlation Coefficient(r)*	
Absolute thickness in resting (mm)		
Paretic side	0.24	**0.57****
Non-paretic side	0.31	0.39
Absolute thickness in activation (mm)		
Paretic side	0.39	**0.67****
Non-paretic side	0.49	0.43
Contraction ratio		
Paretic side	**0.61****	0.15
Non-paretic side	0.23	0.06
Asymmetry		
Resting	0.13	-0.09
Activation	-0.37	-0.10

*Spearman correlation coefficient **Significant correlation (P<0.05)
Contraction ratio :(abdominal thickness in activation state / abdominal thickness in resting state) * 100
Asymmetry : (| 1- abdominal thickness of paretic side / abdominal thickness of non-paretic side |) * 100
TIS: trunk impairment scale, BBS: berg balance scale

Table3. Mann-whitney U test for comparison between the NTG and the PTG

Variables	Subjects(n=24)	NTG(n=12)	PTG(n=12)
Spasticity(MAS)	1.7±1.3	**0.9±1.3***	**2.3±1.1***
Contraction ratio			
Paretic side	167.9±28.5	176.9±37.5	158.9±11.0
Non-paretic side	165.6±30.4	164.2±28.0	167.0±33.8
Asymmetry			
Resting	13.9±9.5	15.6±9.6	12.2±9.5
Activation	15.1±10.8	**9.8±9.8***	**20.3±9.3***
TIS	12.9±4.8	**15.1±4.9 ***	**10.7±3.6***
BBS	42.0±13.0	43.1±12.4	41.0±13.9

Values are presented as mean±standard deviation
*Significant difference (P<0.05) within two groups by Mann-whitney U test.
MAS: modified Ashworth scale, it is calculated G1 as 1, Gr1+ as 2, Gr2 as 3, Gr3 as 4 and Gr4 as 5
Contraction ratio :(abdominal thickness in activation state / abdominal thickness in resting state) * 100
Asymmetry : (| 1- abdominal thickness of paretic side / abdominal thickness of non-paretic side |) * 100