Comparison of the Changes in Thickness of the Abdominal Wall Muscles of Stroke Patients According to the Duration of Their Illness as Observed Using Ultrasonographic Images

DONGKWON SEO, PT, MPT1, 2), SEOUNGWON LEE, PT, PhD1)*, OHSEUNG Kwon, PT, MPT1)

1) Department of Physical Therapy, College of Health and Welfare, Sahmyook University: 26-21 Gongneung2-dong Nowon-gu, Seoul 139-742, Republic of Korea. TEL: +82 2-3399-1630, FAX: +82 2-3399-1639
2) Department of Physical Therapy, Sun Moon University

Abstract. [Purpose] This study was conducted in order to investigate the importance of trunk muscle strength in stroke patients. By comparing the thicknesses of the abdominal wall muscles through ultrasonography, relative to the duration of illness, the results of the objective data were applied. [Methods] Thirty stroke patients were divided into three groups including an acute phase group participating in the study within 1 month after the onset of a stroke (n=10), a subacute phase group participating less than 6 months (n=10) after a stroke, and a chronic phase group participating more than 6 months (n=10) after suffering a stroke. The thicknesses of the transversus abdominis muscles (TrA), internal oblique muscle (IO), and the external oblique muscle (EO) were measured at rest and during abdominal draw-in maneuver (ADIM) in a supine hook-lying position, and their differences were compared. [Results] The results showed that, in comparison of the thicknesses of the paretic and nonparetic sides, the TrA of the subacute phase and chronic phase groups showed significant differences. In addition, the IO of the subacute phase group and the EO of the chronic phase groups also showed significant differences. [Conclusion] According to the duration of illness in stroke patients, the abdominal wall muscles become noticeably infirm and asymmetric. By improving their symmetry, the functions of the trunk muscles can be recovered.

Key words: Stroke, Sonographic image, Abdominal wall muscles

INTRODUCTION

Due to the loss of postural control, stroke patients develop asymmetry of the paretic and nonparetic sides of the body, shifting their weight to the nonparetic side1). And due to the asymmetric posture and cognitive function loss for the midline space, trunk control deteriorates, and thus, normal functional activities cannot be properly performed2). Trunk control is a prognostic factor used to assess the recovery levels of balance, walking and activities of daily living, and it plays an important role in evaluating stroke patients3).

Trunk control is based on supporting muscle strength, endurance and coordinated contraction of the trunk, which is simultaneously controlled by nerves in the bilateral hemispheres. Trunk control is the basis of functional movement and postural control. TrA, IO, and EO are bound together by a single fascia, and they provide the stability and endurance necessary for trunk support4).

However, due to illness-related weakness of the trunk muscles and asymmetric contraction patterns, stroke patients have been observed to use an abnormal postural strategy while performing physical tasks5). As the center of the body moves to the nonparetic side, symmetric weight bearing cannot be achieved, and trunk stability deteriorates6). Eventually, asymmetric contraction of the trunk muscles causes deterioration in balance and functional activity7).

Common tests performed in order to assess the performance ability of the trunk for stroke patients include isokinetic muscle testing, electromyography analysis, computed tomography and motion analysis8). Recent tools developed to assess the performance of trunk control include the Trunk Control Test (TCT), Postural Assessments Scale for Stroke − Trunk Control (PASS-TC), and Trunk Impairment Scale (TIS)9). In recent sonographic studies of normal individuals (control subjects), the right and left sides of the TrA, IO and EO were shown to be symmetrical10). In electromyogram studies, stroke patients were reported to perform asymmetric contraction11).

In our study, stroke patients were divided into three groups including an acute phase, subacute phase, and chronic phase, according to illness duration. Whether or not there was any change in TrA, IO, and EO in each group was objectively determined using sonography.
SUBJECTS AND METHODS

The subjects of this study were 30 stroke patients who were hospitalized at the Konyang University Hospital, in Daejeon, Korea. According to the patient selection standard, the acute phase was defined as a stroke event within 1 month (n=10) of study participation, the subacute phase as a stroke event within 6 months (n=10), and the chronic phase as a stroke event within 6 months (n=10). The recruitment criteria included patients who agreed to participate in the study, patients who could move without assistive devices (FAC 2-4), patients without orthopedic problems affecting the trunk, patients without chronic low back pain, patients who could follow the treatment instructions (MMSE-K > 24),11 and patients without a difference in balance (PASS).

The sonography equipment used in our study was a Logiq sonography system (α-200, Samsung-GE Medical Systems Inc., Seongnam, Korea). Using a 7.5 MHz linear transducer, the thicknesses of the TrA, IO, and EO on the paretic and nonparetic sides were measured during the ADIM and rest period. For the ADIM, the posture that minimized lumbar lordosis by flexion of the hip and the knee joints by 40–80 degrees, was assumed in a supine position. A transducer head was placed 25 mm inside the space between the 12th vertebra and the iliac crest, and the thicknesses were determined by repeated measurements (3 times) during the ADIM and resting period. After sonographic measurement, a horizontal line was drawn in the area, 1.5 cm away from the muscle–fascia junction of the paretic and the nonparetic sides, and the TrA, IO, and EO muscle thicknesses were measured sequentially12, 13).

For the statistical analysis of the results, SPSS 15.0 for Windows was applied. For comparison of the thicknesses of the paretic and nonparetic side deep abdominal muscles of each group, an independent t-test was performed. In order to compare the thicknesses of the deep abdominal muscles of the three groups, an ANOVA was performed. An LSD test was run in order to examine any post hoc differences, whereas significant differences were indicated by the ANOVA. The alpha level was set at 0.05 for all analyses.

RESULTS

The general characteristics of the subjects in our study were as follows. Excluding the duration of illness, of the three groups, gender, age, the affected paretic side, paralysis type, and PASS were not found to be significantly different (p>0.05) (Table 1).

The sonography equipment used in our study showed that the ICC 3,1 for the intra-class reliability for the measurement of all three muscle thicknesses were acceptably high (0.95–0.98). Our study also showed that, in the comparison of the paretic side and nonparetic side of the deep abdominal muscles, significant differences were not shown in the acute phase group (p>0.05). In the subacute and chronic phases during the ADIM and rest periods, only TrA showed significant differences (p<0.05). In addition, IO showed significant differences in the subacute phase group, and EO showed significant differences in the rest period of the chronic phase group (p<0.05) (Table 2). In the comparison of the thicknesses of the deep abdominal muscles of all three groups, according to the duration of illness, only TrA of the paretic and nonparetic sides showed significant difference (p<0.05) (Table 3).

| Table 1. General characteristics of the study subjects |
|--------------------------------------------------------|
| Duration (month) (M±SD) | Acute (n=10) | 1.0±0.0 | Sub-acute (n=10) | 4.5±0.9 | Chronic (n=10) | 47.7±43.7 |
| Sex (male/female) | 5/5 | 7/3 | 4/6 |
| Age (years) (M±SD) | 65.5±9.2 | 56.4±14.4 | 55.5±10.5 |
| Paralysis side (left/right) | 6/4 | 5/5 | 4/6 |
| Type (ischemic/hemorrhage) | 7/3 | 6/4 | 7/3 |
| PASS (point) (M±SD) | 31.5±4.7 | 30.3±5.5 | 31.9±2.7 |

M±SD, mean ± standard deviation; PASS, postural assessments scale for stroke

| Table 2. Comparisons of the paretic and nonparetic side of the abdominal wall muscles |
|--------------------------------------|
| Acute (n=10) | Sub-acute (n=10) | Chronic (n=10) |
|--------------------------------------------------|
| Rest | Contracted | Rest | Contracted | Rest | Contracted |
| TrA (P) | 2.9±0.1 | 4.1±1.0 | 2.6±0.5 | 3.5±0.6 | 2.9±0.9 | 4.1±0.9 |
| TrA (NP) | 3.0±0.1 | 4.3±1.0 | 2.9±0.5* | 4.1±1.1* | 3.4±0.6* | 4.8±0.8* |
| IO (P) | 5.7±1.1 | 6.9±1.4 | 5.6±1.7 | 7.6±2.6 | 6.2±2.0 | 8.0±2.6 |
| IO (NP) | 5.9±1.1 | 7.4±1.3 | 6.4±1.9* | 8.1±3.0 | 6.3±1.8 | 8.3±2.4 |
| EO (P) | 3.0±0.1 | 3.0±1.0 | 3.5±1.2 | 3.6±1.0 | 3.8±0.9 | 4.1±0.8 |
| EO (NP) | 3.0±0.1 | 3.0±1.0 | 3.7±1.9 | 3.8±1.0 | 4.2±1.1* | 4.3±1.0 |

Values are means ± SD.
TrA, transverse abdominal muscle; IO, internal oblique muscle; EO, external oblique muscle; P, paretic side; NP, non-paretic side.
*Significantly different from paretic side (p<0.05)
the research reported by Karatas, et al. 16), trunk muscle in the subacute phase and chronic phase groups. Based on paretic and nonparetic sides revealed significant differences of the acute phase group, the muscle thicknesses of the paragraph...

|                      | Acute (n=10) | Sub-acute (n=10) | Chronic (n=10) |
|----------------------|--------------|------------------|---------------|
| TrA                  | 0.1±0.2      | 0.4±0.8          | 0.7±0.8       |
| IO                   | 0.2±0.1      | 0.8±0.4          | 0.8±0.6       |
| EO                   | 0.1±0.2      | 0.3±0.4          | 0.4±0.5       |

Values are means ± SD. TrA, transverse abdominal muscle; IO, internal oblique muscle; EO, External oblique muscle.

*Acute < chronic (p<0.05)

DISCUSSION

The results of our study showed that, in the comparison of the three groups divided according to the duration of illness, significant differences were observed for the value of TrA (symmetry). The results were similar to those reported in an electromyogram study by Dickstein, et al.14, who found delayed paretic side contraction in comparison to the nonparetic side in stroke patients. Due to this abnormal contraction, the symmetrical contraction of the bilateral abdominal muscles was significantly reduced, a finding that supports our study result indicating that the asymmetry became more severe with the duration of illness. Notable in our study, only TrA showed a difference, an observation considered to be the result of the characteristic activity and function of TrA. When the limbs move during normal motion, the TrAs contract first. While walking, they contract continuously until the walking speed reaches a certain rate. They also contract under the conditions of routine activities and, on account of this reason, asymmetrical differences produce more severe results in comparison with other trunk muscles15).

In addition, as seen in the results of our study upon exclusion of the acute phase group, the muscle thicknesses of the paretic and nonparetic sides revealed significant differences in the subacute phase and chronic phase groups. Based on the research reported by Karatas, et al.16, trunk muscle strength decreases in stroke patients in comparison with normal individuals, and their muscles contract asymmetrically. It was observed that the muscle thicknesses of the paretic side of the stroke patients showed more significant differences than those of the nonparetic side. It has been hypothesized that the cause of the weakening of the trunk muscles in stroke patients is that the trunk muscles are affected by the bilateral cerebral hemisphere. Thus, even if a cerebral lesion occurred on one side, the weakening occurs bilaterally14). Considering that a research report found that the weakening of the extension muscle strength of the trunk causes weakening of the deep abdominal muscles, more comprehensive studies are required11. Furthermore, in our study, the number of subjects was too small to generalize the results. In addition, previous sonographic studies have reported that the right and left abdominal muscles of normal individuals contract symmetrically, and our study had the limitation of not including control subjects. Based on our results, studies on the effectiveness of therapeutic intervention methods for improving the symmetry of the deep abdominal muscles of stroke patients may be required. In conclusion, the results of our study showed that, depending on the duration of illness, stroke patients developed asymmetry of the abdominal muscles (in particular, TrAs) and that the asymmetry became more severe as the duration of illness became longer. These findings contain important clinical significance for the development of a therapeutic strategy for treating stroke patients. Therefore, our data and findings should be applied to clinical therapeutic intervention.

REFERENCES

1) Sackley CM: Falls, sway, and symmetry of weight-bearing after stroke. Int Disabil Stud, 1991, 13: 1–4. [Medline][CrossRef]
2) Ryerson S, Byl NN, Brown DA, et al.: Altered trunk position sense and its relation to balance functions in people post-stroke. J Neurol Phys Ther, 2008, 32: 14–20. [Medline]
3) Hsieh CL, Sheu CF, Hseuh IP, et al.: Trunk control as an early predictor of comprehensive activities of daily living function in stroke patients. Stroke, 2002, 33: 2626–2630. [Medline][CrossRef]
4) Hodges PW, Gurfinkel VS, Brunaghe S, et al.: Coexistence of stability and mobility in postural control: evidence from postural compensation for respiration. Exp Brain Res, 2002, 144: 293–302. [Medline][CrossRef]
5) Campbell FM, Ashburn AM, Pickering RM, et al.: Head and pelvic movements during a dynamic reaching task in sitting: implications for physical therapists. Arch Phys Med Rehabil, 2001, 82: 1655–1660. [Medline][CrossRef]
6) Geiger RA, Allen JB, O’Keefe J, et al.: Balance and mobility following stroke: effects of physical therapy interventions with and without biofeedback/forceplate training. Phys Ther, 2001, 81: 995–1005. [Medline]
7) Dickstein R, Shefti S, Ben Haim Z, et al.: Activation of flexor and extensor trunk muscles in hemiparesis. Am J Phys Med Rehabil, 2000, 79: 228–234. [Medline][CrossRef]
8) An SH CY, Pack SP: The effects of trunk control ability on balance, gait, and functional performance ability in patients with stroke. Korea academy of university trained physical therapists, 2010, 15: 31–42.
9) Verheyden G, Nieuwboer A, Van de Winckel A, et al.: Clinical tools to measure trunk performance after stroke: a systematic review of the literature. Clin Rehabil, 2007, 21: 387–394. [Medline][CrossRef]
10) Rankin G, Stokes M, Newham DJ: Abdominal muscle size and symmetry in normal subjects. Muscle Nerve, 2006, 34: 320–326. [Medline][CrossRef]
11) Park JH: Standardization of korean version of the Mini-Mental State Examination (MMSE-K) for use in the elderly. Part II. Diagnostic validity. J Korean Neuropsychiatr Assoc, 1989, 28: 508–513.
12) Stets DM, Freund JE, Allison SC, et al.: A rehabilitative ultrasound imaging investigation of lateral abdominal muscle thickness in healthy aging adults. J Geriatr Phys Ther, 2009, 32: 60–66. [Medline][CrossRef]
13) Hodges PW, Pengel LH, Herbert RD, et al.: Measurement of muscle contraction with ultrasound imaging. Muscle Nerve, 2003, 27: 682–692. [Medline][CrossRef]
14) Dickstein R, Shefti S, Marcovitz E, et al.: Anticipatory postural adjustment in selected trunk muscles in post stroke hemiparetic patients. Arch Phys Med Rehabil, 2004, 85: 261–267. [Medline][CrossRef]
15) Saunders SW, Rath D, Hodges PW: Postural and respiratory activation of the trunk muscles changes with mode and speed of locomotion. Gait Posture, 2004, 20: 280–290. [Medline][CrossRef]
16) Karatas M, Cetin N, Bayramoglu M, et al.: Trunk muscle strength in relation to balance and functional disability in unihemispheric stroke patients. Am J Phys Med Rehabil, 2004, 83: 81–87. [Medline][CrossRef]