Comparison of symmetry and contracted ratio in thickness of the abdominal muscles using ultrasonography in healthy adults and stroke patients

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Abstract. This study was investigated symmetry and contracted ratios of the lateral abdominal muscles (LAM) in stroke patients and the healthy adults. Twenty-six stroke patients and 35 healthy adults were participated. The thicknesses of transverse abdominis (TrA), internal oblique (IO), and external oblique (EO) muscles on the paretic/non-paretic (left/right) sides were measured during contraction and rest period. Comparison of symmetric ratio of the two groups showed significant difference in all abdominal muscles, but not EO during contraction. Comparison of contracted ratio of the two groups showed significant difference in TrA, but not IO and EO. This study found asymmetry in LAM, and contracted ratio of TrA was decreased in stroke patients. These results revealed that recovery of TrA is needed for stroke patients.

Keywords: stroke, abdominal muscles, ultrasonography

1 Introduction

Stroke patients experience problems in functional activity due to weight asymmetry [1]. Weight asymmetry is deeply related to trunk asymmetry. Stroke patients have trunk asymmetry, inability to maintain the midline due to injured trunk position sense in the transverse and sagittal plane, damaging trunk performance and negatively affecting balance and gait [2,3]. Therefore, trunk symmetry plays an important role in functional recovery of stroke patients.

Trunk muscles provide stability as a prime mover, by contracting first when the body or extremities move or as an anticipatory postural adjuster while the extremities move, and function in proper performance of the trunk [4]. However, stroke patients show delayed contraction in the affected the latissimus dorsi, external oblique (EO), and rectus abdominis muscles (RA), showing decreased function as a trunk stabilizer, affecting functional activities and showing compensatory patterns [4,5]. In addition, EO of the non-paretic side was compensated for RA deficit in stroke patients during therapeutic exercise [6].

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Ultrasound images can be used instead of computed tomography and invasive needle electromyography (EMG) for measurement of core muscles. In the beginning, the ultrasound image of trunk muscles was used as an assistive method for accurate placement of the needle of needle EMG in the deep TrA muscles [4]. However, ultrasound images are used specifically for training and learning movements by visual feedback during therapeutic exercise, not just for studies on muscle thickness or symmetry using images of the internal oblique (IO), EO, and TrA, which provide trunk stability through functional coordination activities; it is also commonly used before and after treatment for evaluation of treatment effects, and is used as a training tool [7-9]. Ultrasonography is easily used noninvasively, has no risk of radiation, and is low-priced; therefore, used well. However, few studies have reported on changes in trunk muscles of stroke patients using ultrasound images, and there is no aging-matched study. Therefore in this study, stroke patients and aging-matched people’s trunk muscles (TrA, IO, EO) were measured through ultrasound images. Thickness, symmetry, and contracted ratio changes were compared and are provided.

2 Methods

2.1 Participants

Twenty six stroke patients treated at K University Hospital and 35 aging matched adults who live in the community participated in this study. All subjects provided written informed consent prior to participation. The inclusion criteria of the stroke group (SG) were 1) post-stroke time $\geq$ 12 months, 2) able to walk without assistance, 3) no orthopedic problems that affected the trunk, 4) no chronic lower back pain, 5) fair to good cognition (MMSE-K > 24 point), 6) no unilateral neglect, hemianopsia, or apraxia, and 7) no psychological or emotion problems. The inclusion criteria of the healthy adult group (AG) were 1) able to walk without assistance, 2) no orthopedic problems that affected the trunk, 3) no chronic lower back pain, and 4) able to understood the directions. The study protocol was approved by the institutional review board.

2.2 Ultrasonography

Ultrasonography equipment was used in this study (MySono U5, Samsung Medison Co., Seoul, Korea). Using a 7.5 MHz linear transducer, the thicknesses of TrA, IO, and EO on the paretic and the non-paretic sides in SG and on the left and right sides in AG were measured during the contraction and rest periods. Abdominal draw-in maneuver (ADIM) was performed for measurement of contraction position. The transducer head was placed 25 mm internally between the 12th rib and iliac crest, and measured twice; contraction and rest period. Each measurement was repeated three times, and the average was used. For contraction, subjects lie supine, comfortably flexing the hip joint and knee joint, minimizing lordosis, and pull up the lower abdomen [8,10]. Five minutes were given before the measurement in order to allow
practice for accurate posture. For contraction (ADIM) practice, patients looked at the monitor screen, and the therapist provided visual feedback for accurate contraction by looking into the monitor. After ultrasound imaging measurement, muscle thickness was measured by drawing a line from the left end to the right end of the image, 1.5 cm apart from the muscle-fascia junction, and a horizontal line was drawn for measurement of TrA, IO, and EO, which were measured in order [11].

2.3 Experimental Methods

Subjects were positioned in a crook-lying supine position with their hip and knee flexed. Their arms were positioned straight on the bed. The lumbar spine was in neutral position. During this study, two postures were assessed; (1) rest, (2) contraction. Rest is measured in expiration of a normal respiratory pattern, and contraction is measured on maintaining respiration after abdominal draw - in maneuver (ADIM) on 2/3 of normal expiration. Rest expiration position was used as a baseline measure for calculating the change in TrA, IO, and EO. All positions were repeated three times and performed randomly. Subjects practiced each position prior to data procedure. The verbal instruction for ADIM was “hold breathe after tidal expiration, and then move your navel toward the lower back”. ADIM was performed without movement of the lumbar spine, pelvis, and rib cage. This study compared symmetric and contracted ratio after measurement of thickness of abdominal muscles. Symmetric ratio is calculated by ratio (dominant / non-dominant) (non-paretic side / paretic side), contracted ratio is calculated by ratio (contraction / rest) [8,10].

2.4 Statistical analysis

In this study, SPSS 15.0 for Windows was applied for statistical analysis of the results. Data normality was tested with Shapiro - Wilk; all variables were normal distribution. Independent t-test and Chi test were used for the homogeneity test. An independent t-test was performed for comparison of the thicknesses lateral abdominal muscles of each group. An independent t-test was performed for comparison of symmetric and contracted ratio of the lateral abdominal muscles of the two groups. The alpha level was set at 0.05 for all analyses.

3 Results

3.1 General information

In comparison of the general characteristics of the SG and AG individuals, age (57.96 ± 13.49 yrs vs 61.94 ± 6.82 yrs), weight (62.96 ± 8.31 kg vs 60.69 ± 7.14 kg), and height (163.04 ± 7.34 cm vs 159.69 ± 8.63 cm) were not significantly different (p>0.05). In addition, 14/12 stroke patients had (left/right) hemiplegia, and an MMSE-k score of 27.50 ± 1.84; 14/12 had lesion type (cerebral infarction/cerebral
hemorrhage, and 12/14 had an MMSE-k score of 27.50 ± 1.84, and onset duration of 20.31 ± 33.52 months.

3.2 Comparison of the symmetry and Contracted ratio of abdominal muscles

Symmetry of the two groups (Left/Right) was compared, and showed significant difference in TrA (rest), IO (rest), EO (rest), TrA (ADIM), and IO (ADIM) (p<0.05), but not EO (ADIM). Therefore, SG showed larger differences than AG.

In comparison between the two groups, the contracted ratio (contraction/rest) showed significant difference between the paretic TrA and non-paretic TrA (p<0.05), but not IO and EO (Fig 1).

![Fig. 1. A: Symmetry of abdominal muscles. Black and white dots are represented as stroke and adult groups respectively. Solid and dotted lines are represented as rest and ADIM conditions respectively. B: Contracted ratio of abdominal muscles. Black and white dots are represented as stroke and adult groups respectively. Solid and dotted lines are represented as paretic (non-dominant) and non-paretic (dominant) sides respectively. Abbreviations are TrA; transverse abdominis, IO; internal oblique, and EO; external oblique.]

4 Discussion

In this study, as a method for analysis of measured thickness, symmetry is used because use of personal ratio cannot compare the factors between subjects. Contracted ratio is used because muscle thicknesses cannot be compared, and each ratio was calculated, normalized, and then compared [8,10,12].

The contracted ratio of stroke TrA ratio was approximately 1.4, elders showed 1.6 times the value, showing the highest ratio. This result supports those from previous studies showing that stroke patients have delayed onset, lower ratio on EMG, compared to normal subjects [5,13], and trunk strength of stroke patients was decreased, compared with normal elderly people [14].

A previous study analyzed the contracted ratio, and reported that TrA ratio for subjects with chronic lower back pain was approximately 1.65-1.75, similar to that of...
the elders, however, a difference was observed in stroke patients [12]; in a study with other normal subjects, approximately 1.4 was obtained, and values similar to those of stroke patients were recorded [8,9]. However, in the studies mentioned above, only a wide range of subjects, from teenagers to those in their late 60s, were studied; direct comparison of the results of aging matched in this study is difficult, however the comparison is meaningful. It will help clinicians in making decisions.

The results of this study, particularly those regarding symmetry, showed that stroke patients had more asymmetric TrA, IO, and EO, compared to healthy adults. Non-paretic TrA ratio had a larger contraction rate, and TrA ratio of the paretic side had a smaller contraction ratio.

Results like these demonstrated that stroke patients had more asymmetric TrA, compared to the aged, and asymmetric contraction was observed. In previous studies, stroke patients had weaker muscle power than normal subjects; the weakness was in the paretic side, compared to the non-paretic side, and delayed contraction was observed [14]. These stroke patients have decreased trunk control, cannot perform as a prime mover, and these were the results. The results will provide basic data for therapeutic exercise for recovery of TrA in stroke patients.

5 Conclusion

This study found that asymmetry in abdominal muscles, and contracted ratio of TrA was decreased in stroke patients. These results indicate that recovery of TrA is needed for patients with stroke. Further study will be conducted for specific exercise for recovery of TrA in patients with stroke.

References


