The effects of visual biofeedback using ultrasonography on deep trunk muscle activation

Hyun-Gyu Cha, PT, PhD1), Myoung-Kwon Kim, PT, PhD2)*, Young-Jun Shin, PT, MS2)

1) Department of Physical Therapy, College of Kyungbuk, Republic of Korea
2) Department of Physical Therapy, College of Rehabilitation Sciences, Daegu University: Jillyang, Gyeongsan, Gyeongbuk 712-714, Republic of Korea

Abstract. [Purpose] The objective of this study is to investigate the effect of visual biofeedback using ultrasonography on the functional improvement of deep trunk muscle. [Subjects and Methods] This study selected ten healthy people without orthopedic history and information on the study. The average ages, heights, and weights were 22.70 ± 2.06 years old, 171.15 ± 9.18 cm, and 66.86 ± 8.88 kg in the experimental group, respectively. The abdominal drawing-in maneuver were executed for subjects through monitoring the status of muscle contraction using ultrasonic waves. And motor control exercises were performed during 6 weeks, 20 minutes/day and three times/week. We collected the data using electromyography MP150 system (BIOPAC system Inc., CA, USA) in order to measure trunk muscle activation. [Results] The subjects showed significant improvements in Internal oblique abdominis and lumbar multifidus muscle after intervention. [Conclusion] Visual biofeedback training using ultrasonography might be effective in improving function of the deep trunk muscle.

Key words: Visual biofeedback, Ultrasonography, Deep trunk muscle

INTRODUCTION

It is known that core stability can enhance the muscles located nearby abdomen, lumbar spine and pelvis1) and play important role to improve balance ability and trunk stabilization2). Core muscles are composed of the muscles of nearby abdomen and pelvis, such as rectus abdominis, external/internal oblique abdominis, transverse abdominis, erector spinae, quadratus lumborum, multifidus, gluteus medius3). Those muscles are playing an important role providing stabilization during moving legs and arms. Among them, it is known that transverse abdominalis and multifidus provide spinal stabilization to deep muscles4). In order to strengthen core muscles, various methods of exercises such as swiss ball5) and bridge exercise6) are used. But the lack of studies and definite evidences are founded whether those methods are effective to deep muscles such as transverse abdominalis and multifidus. ADIM is a kind of exercise technique to increase intra-abdominal pressure by pulling lower abdomen without moving spine and pelvis7), and possible to contract transverse abdominalis and multifidus selectively, which is utilized for spinal stabilization exercise8). Lee et al.9) reported the muscle activation of trunk muscles is increased when back pain patients who are instable on lumbar spine exercise ADIM, and Chon et al.8) reported the muscle activation of deep core muscles is increased when the patients perform ADIM including dorsiflexion. But in the review of preceding research, most studies are executed on muscle activation of deep muscle by simply applying ADIM. Therefore, the purpose of this study was to investigate the effects of visual biofeedback using ultrasonography on muscle activity of the deep trunk muscle in healthy adults.
SUBJECTS AND METHODS

This study selected ten healthy people without orthopedic history. Information on the study and written informed consent according to the ethical standards of the Declaration of Helsinki were provided to all subjects prior to their participation, and all agreed to participate in the project. The average ages, heights, and weights were 22.70 ± 2.06 years old, 171.15 ± 9.18 cm, and 66.86 ± 8.88 kg in the experimental group, respectively.

The ADIM (abdominal Drawing-in Maneuver) are executed for subjects through monitoring the status of muscle contraction using ultrasonic waves. And motor control exercises are performed during 6 weeks, 20 minutes/a day and three times/a week.

Ultrasonic measurement for the thick of transverse abdominal muscle is executed by positioning the probe to the center of upper parts on iliac crest at central midaxillary line in the right. And in order to reduce measurement error, we selected an expert who is 5 years more experienced in ultrasonic measurement field.

We firstly asked the subject to pose putting a pillow under the head, bending hip and knee joint to 60 degrees, and taking crook-lying position, and adjust monitor position for them to watch the ultrasonic image (achieve CST, V2U Healthcare, Pte, Ltd., Singapore) at ease. During the exercise, therapist gives instructions orally to the subject “please make your abdomen constriction like drawing your belly with the utmost effort while breathing as usual”, and subject execute the exercise by checking on his transverse abdominal muscle contraction via the monitor. Total time of exercise are 20 minutes; allowing the subject to rest for 10 minutes after contraction of transverse abdominal muscle for 10 minutes.

We collected the data using electromyography MP150 system (BIOPAC system Inc. CA, USA) in order to measure trunk muscle activation. We measured electrical activities by using electromyogram electrode attached to the area of muscular fiber and pressing muscle parts following the direction of muscle texture in order to find the positions.

The attached locations of surface electrodes were as follows: (1) for rectus abdominis: 5 cm from top of belly, (2) for Internal oblique abdominis: the middle point between belly line and ASIS, (3) for Internal oblique abdominis: in the center of the triangle formed by a horizontal line between the anterior superior iliac spine of the innominate and the umbilicus, midline, and the inguinal ligament, (4) for lumbar multifidus: 2 cm lateral to the spinoous process at the L4–L5 interspace.

We executed bridge exercise to measure muscle activity at reference voluntary contraction of each muscle. After we collected the data value for 5 seconds at maximal voluntary isometric contraction of each muscle, and used the amount of average electromyographic signals reference voluntary contraction (%RVC) during only 3 seconds excluding 2 of beginning and 1 of latter part from total 5. Average value was obtained from 3 times of measurements.

RESULTS

The subjects showed significant improvements in Internal oblique abdominis and lumbar multifidus muscle after intervention (p<0.05) (Table 1).

|                      | EG (n=10)         |
|----------------------|-------------------|
| **Rectus abdominis** |                   |
| Pre-test             | 10.6 ± 4.0*       |
| Post test            | 12.2 ± 3.7        |
| Change value         | 1.6 ± 6.4         |
| **External oblique abdominis** |         |
| Pre-test             | 12.6 ± 2.8        |
| Post test            | 13.8 ± 3.9        |
| Change value         | 1.2 ± 3.6         |
| **Internal oblique abdominis** |             |
| Pre-test             | 16.8 ± 4.9        |
| Post test            | 22.0 ± 4.3**      |
| Change value         | 5.2 ± 4.5         |
| **Lumbar multifidus** |                   |
| Pre-test             | 17.0 ± 7.4        |
| Post test            | 23.9 ± 2.9**      |
| Change value         | 6.9 ± 6.1         |

EG: visual biofeedback group using ultrasonography
*p<0.05, **p<0.01
DISCUSSION

In this study, we compared and analyzed the muscle activation for trunk muscle activation, especially surface muscle of rectus abdominis, external oblique abdominis, and deep muscles of Internal oblique abdominis, lumbar multifidus using visual feedback of ADIM which conduct targeting health adults. As like the above, in the preceding research by using visual feedback, Kim et al.\textsuperscript{13} showed the subject’s contraction exercise of pelvic floor muscle through visual feedback can increase muscular activation in transverse abdominis and its thickness is thicker. Also, Park et al.\textsuperscript{14} report breathing exercise using visual feedback can increase pulmonary function and respiration muscle activation significantly. Recently, this visual biofeedback is used to care the stroke patients. Lee et al.\textsuperscript{15} report that visual perception and sitting balance are improved when visual biofeedback training is conducted for stroke patients. The current study has some limitations. First, the small sample size may have influenced the results. Second, the absence of follow-up after the end of the intervention does not allow for determination of the durability of the effect of this therapy. Further studies, including a long-term follow-up assessment, are needed to evaluate the long term benefits of visual biofeedback therapy.

REFERENCES

1) Marshall PW, Murphy BA: Core stability exercises on and off a Swiss ball. Arch Phys Med Rehabil, 2005, 86: 242–249. [Medline] [CrossRef]
2) Kim JS, Kim YH, Kim EN, et al.: Which exercise is the most effective to contract the core muscle: abdominal drawing-in maneuver, maximal expiration, or kegel exercise? J Korean Soc Phys Med, 2016, 11: 83–91. [CrossRef]
3) Kim SG, Yong MS, Na SS: The effect of trunk stabilization exercises with a swiss ball on core muscle activation in the elderly. J Phys Ther Sci, 2014, 26: 1473–1474. [Medline] [CrossRef]
4) Hodges PW: Is there a role for transversus abdominis in lumbo-pelvic stability? Man Ther, 1999, 4: 74–86. [Medline] [CrossRef]
5) Park J, Lee S, Hwangbo G: The effects of a bridge exercise with vibration training and an unstable base of support on lumbar stabilization. J Phys Ther Sci, 2015, 27: 63–65. [Medline] [CrossRef]
6) Lee HJ, Kim SY: Comparison of the effects of abdominal draw-in and expansion maneuvers on trunk stabilization in patients with low back pain and lumbar spine instability. Phys Ther Korea, 2015, 22: 37–48. [CrossRef]
7) Hodges PW, Richardson CA: Inefficient muscular stabilization of the lumbar spine associated with low back pain. A motor control evaluation of transversus abdominis. Spine, 1996, 21: 2640–2650. [Medline] [CrossRef]
8) Chon SC, Chang KY, You JS: Effect of the abdominal draw-in manoeuvre in combination with ankle dorsiflexion in strengthening the transverse abdominal muscle in healthy young adults: a preliminary, randomised, controlled study. Physiotherapy, 2010, 96: 130–136. [Medline] [CrossRef]
9) Whittaker JL: Ultrasound imaging for rehabilitation of the lumbopelvic region. Churchill Livingstone, 2007, pp 120–140.
10) Hungerford B, Gilleard W, Hodges P: Evidence of altered lumbopelvic muscle recruitment in the presence of sacroiliac joint pain. Spine, 2003, 28: 1593–1600. [Medline] [CrossRef]
11) Cram JR, Kasman GS, Holtz J: Introduction to surface electromyography, 5th ed. Gaithersburg: Aspen, 1998.
12) Choi SA, Cynn HS, Yi CH, et al.: Isometric hip abduction using a Thera-Band alters gluteus maximus muscle activity and the anterior pelvic tilt angle during bridging exercise. J Electromyogr Kinesiol, 2015, 25: 310–315. [Medline] [CrossRef]
13) Kim JH, Cho SH, Jang HJ: The effects of precise contraction of the pelvic floor muscle using visual feedback on the stabilization of the lumbar region. J Phys Ther Sci, 2014, 26: 605–607. [Medline] [CrossRef]
14) Park HK, Kim YJ, Kim TH: The role of visual feedback in respiratory muscle activation and pulmonary function. J Phys Ther Sci, 2015, 27: 2883–2886. [Medline] [CrossRef]
15) Lee SW, Shin DC, Song CH: The effects of visual feedback training on sitting balance ability and visual perception of patients with chronic stroke. J Phys Ther Sci, 2013, 25: 635–639. [Medline] [CrossRef]