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Original Article

Comparison of abdominal muscle thickness according to feedback method used during abdominal hollowing exercise

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Abstract. [Purpose] This study was intended to examine the most effective feedback method for contracting the musculus transversus abdominis muscle by using basic training, a pressure biofeedback unit, and real-time ultrasonographic imaging during abdominal hollowing exercise training. [Subjects and Methods] The subjects in this study were 30 healthy young students in their twenties. Thirty subjects were divided randomly and equally into the basic training, the pressure biofeedback unit, and real-time ultrasonographic imaging groups. All of the subjects received abdominal hollowing exercise training for 15 minutes. The subjects in the pressure biofeedback unit group were trained by using a pressure biofeedback unit. Those in the real-time ultrasonographic imaging group received training with monitoring of possible contraction of their musculus transversus abdominis muscles on ultrasonography. [Results] In all the three groups, the musculus transversus abdominis became significantly thicker, but more significantly in the real-time ultrasonographic imaging group than in the basic training group. [Conclusion] The feedback method using real-time ultrasonographic imaging may be more effective in thickening the musculus transversus abdominis muscle during exercise than the traditional feedback method with manual contact only. However, it is insufficient in terms of overall qualitative improvement of exercise outcome.
Key words: Transversus abdominis, Real-time ultrasonographic imaging, Pressure biofeedback unit

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INTRODUCTION

The musculus transversus abdominis muscle contributes to stabilizing the spine and thoracic cage, and prevents unnecessary relaxation of the sacroiliac joint, thereby elevating abdominal pressure and diffusing weight support concentrated on the spine[1)]. To strengthen the musculus transversus abdominis, an abdominal hollowing exercise (AHE) is used[2)]. To induce precise muscle contraction, different types of feedback are used, such as manual contact, electromyography, a pressure biofeedback unit (PBU), and real-time ultrasonographic imaging (RUSI)[3)]. Nonetheless, manual contact and oral commands cannot present objective numerical values, and thus could not be used to verify whether appropriate contraction and improvement have occurred. Surface electromyography cannot measure the musculus transversus abdominis because it exists deep inside the body. Electromyography using needle electrodes carries the risk of infection and is costly; hence, its utilization is restricted in the clinical field[4)]. On the other hand, a PBU and RUSI are noninvasive methods used widely in the clinical field[5)]. A PBU is inexpensive and portable, and its positive effects are expected for motivation during exercise[6)]. RUSI can also depict muscle contraction relatively precisely on a real-time basis and exhibits high reliability and validity[7)].

However, research on the most effective feedback method for contraction training of the musculus transversus abdominis is lacking. Accordingly, this study is intended to examine the most effective feedback method for contracting the musculus transversus abdominis muscle by using basic training, a PBU, and RUSI during AHE training.

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SUBJECTS AND METHODS

The subjects in this study were 30 healthy young students in their twenties who were attending Youngdong University in Chungbuk, South Korea. Subjects were included if they had no musculoskeletal or neurological disorders affecting the upper or lower extremities, lesions, or history of surgery of the spine or upper extremities. The subjects were selected randomly among those who met the above-mentioned criteria. Thirty subjects were divided randomly and equally into the basic training group (BTG), PBU group (PBUG), and RUSI group (RUSIG). The mean age, height, and weight of the subjects in each group were as follows, without significant differences between the groups: in the BTG, 21.1 ± 1.1 years, 167.4 ± 6.5 cm, and 57.0 ± 7.1 kg, respectively; and in the PBUG, 20.7 ± 1.3 years, 166.9 ± 6.3 cm, and 55.3 ± 5.4 kg, respectively; in the RUSIG, 20.3 ± 0.7 years, 167.6 ± 6.3 cm, and 55.9 ± 6.7 kg, respectively. Ethical approval for the study was granted by the institutional review board of Youngdong University. All the subjects were fully informed of the objectives and methods of the study beforehand and provided informed consent to participate in the experiments.

All of the subjects received AHE training for 15 minutes. They were in a crooked lying position with their knees flexed to 90°. While continuing comfortable respiration as usual, they strained the navel in the direction of the anus and the anus in the direction of the navel, and slowly moved their lower abdomen inward while pulling the pelvic floor muscle upward so that the pelvic floor muscle could contract[8]. At this time, the subjects in the BTG were trained only with basic training and manual contact. Those in the PBUG located the PBU (Stabilizer, Chattanooga Group Inc., USA) on the lumbar region and were told to maintain the manometer at 10 mm Hg, starting from 40 mm Hg. The subjects in the RUSIG received training with monitoring of possible contraction of their musculus transversus abdominis muscles on ultrasonography.

After training for 15 minutes, the thicknesses of the musculus transversus abdominis, internal oblique abdominal, and external oblique abdominal muscles in all of the subjects were measured three times when the subjects were at rest in a supine position and performed the AHE with which they were trained. For measurement, the ultrasonographic probe was placed in the middle, between the 11th costal cartilage and the iliac crest, and the space where the musculus transversus abdominis and thoracolumbar fascia met was made to appear at the right side of the ultrasonographic image[9].

To examine changes in the thickness of each muscle during rest and AHE in each group, a paired t-test was conducted. To compare differences in the thickness of each muscle during rest and during AHE, one-way analysis of variance was performed, and a Bonferroni post hoc test was performed. The level of statistical significance was set at p=0.05.

RESULTS

In all the three groups, the musculus transversus abdominis muscle became significantly thicker, but the thicknesses of the internal oblique abdominal and external oblique abdominal muscles did not differ significantly during AHE as compared with the rest period (p>0.05). During AHE, the thickness of the musculus transversus abdominis differed significantly among the groups (p<0.05). In the post hoc analysis, no significant difference was observed between the BTG and the PBUG, and between the PBUG and the RUSIG (p>0.05). Meanwhile, the musculus transversus abdominis was significantly thicker in the RUSIG than in the BTG (p<0.05). No significant difference was observed among the three groups regarding the thicknesses of the internal oblique abdominal and external oblique abdominal muscles during AHE (p>0.05; Table 1).

Table 1. Comparison of thickness of abdominal muscle according to the methods of feedback during abdominal hollowing exercise (unit: mm)

		BTG	PBUG	RUSIG	post-hoc
TA	pre	2.9 ± 1.0	2.7 ± 0.8	2.8 ± 0.9	-
	post[†]	4.4 ± 1.2**	5.0 ± 1.2**	6.1 ± 1.9**	BTG, PBUG< <PBUG,RUSIG
	diff[†]	1.5 ± 1.3	2.3 ± 1.2	3.3 ± 1.7	BTG, PBUG< <PBUG,RUSIG
IOA	pre	6.4 ± 1.3	6.5 ± 1.5	6.1 ± 1.7	-
	post	8.1 ± 2.2*	9.1 ± 9.1**	9.0 ± 2.3**	-
	diff	1.7 ± 1.8	2.6 ± 1.1	2.9 ± 1.9	-
EOA	pre	4.1 ± 0.8	4.6 ± 1.2	3.8 ± 0.8	-
	post	4.7 ± 1.4	5.4 ± 1.3	4.4 ± 1.2	-
	diff	0.6 ± 1.2	0.8 ± 1.2	0.6 ± 1.2	-

*pre-post paired t-test: *p<0.05, **p<0.01; †BTG-PBUG-RUSIG ANOVA: †p<0.05
BTG: Basic training Group; PBUG: Pressure Biofeedback Unit Group; RUSIG: Real-time UltraSound Group; TA: transversus abdominis; IOAM: Internal Oblique Abdominal Muscle; EOAM: External Oblique Abdominal Muscle

DISCUSSION

In this study, the musculus transversus abdominis muscle was thicker in the RUSIG than in the BTG during AHE. Regarding this, Gwon et al. reported that the musculus transversus abdominis muscles of the subjects who received feedback using RUSI were thicker than those of the subjects who used a traditional feedback method, which is consistent with the result of the present study[10]. Henry and Westervelt also observed that the subjects who received feedback using RUSI needed less practice to embody precise AHE than the subjects in the other groups, supporting the results of the present study[11]. Meanwhile, no significant difference in the thickness of the musculus transversus abdominis muscle was observed between the BTG and the PBUG. Regarding this, von Garnier et al. reported that the interobserver reliability of the PBU was low[12], and Lima et al. observed that the preciseness of diagnoses made by using a PBU was doubtful[13].

Rackwitz et al.[14] asserted that selective contraction of the musculus transversus abdominis muscle was necessary to heighten therapeutic performance, but the muscle is difficult to contract selectively[15]. The musculus transversus abdominis muscle became thicker not only in the BTG but also in the PBUG and RUSIG. In addition, during exercise, a significant difference in the musculus transversus abdominis was observed between the BTG and the RUSIG, but not between the PBUG and the RUSIG. Given the above-mentioned findings, the feedback method using RUSI may be more effective than the traditional feedback method with manual contact only in thickening the musculus transversus abdominis muscle during exercise. However, RUSI is insufficient in terms of overall qualitative improvement of exercise outcome. Therefore, development of appropriate oral commands together with ultrasonography is considered necessary, as is development of contents equipped with interface and games for children or patients lacking in understanding of RUSI. In addition, research on selective changes in thickness of the musculus transversus abdominis muscle when a PBU is used together with certain oral commands and contents should be conducted. This study was concerned only with healthy subjects in their twenties in a certain geographic area, and the number of subjects was small. Therefore, in the future, an experiment with a larger number of subjects with more-diverse diseases should be conducted.

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