The Evaluation Of Trunk Muscles After Trunk Exercises Using The Diffusion-Weighted Magnetic Resonance Imaging

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ABSTRACT

Introduction:
Trunk exercises are often prescribed for patients and athletes to treat or prevent low back injuries. For considering more effective exercises, to investigate the activity of deep trunk muscles during trunk exercises is needed. The electromyography and magnetic resonance imaging (MRI) have been using for assessing the muscle activity and recruitment during exercises. Although the electromyography is used generally to investigate the muscle activity, invasive procedure is inevitable to evaluate the activity of the deep trunk muscles, such as the fine-wire or needle electrodes. On the other hand, MRI is a non-invasive investigation device and able to assess the recruitment of the deep trunk muscles. Previous study which used T2-weighted imaging and diffusion-weighted imaging (DWI) reported that the T2 value and apparent diffusion coefficient (ADC) value of the activated muscles increased immediate after the exercises.

Although the activity of the transversus abdominis and multifidus during trunk exercises has been reported, the activity of the psoas major and quadratus lumborum has not been studied yet. MRI is able to assess the psoas major and quadratus lumborum easily and DWI is able to scan in a shorter time than T2-weighted imaging. For assessing the recruitment of trunk muscles using the MRI, breath-hold scan is needed. Therefore, the purpose of this study was to evaluate the muscle recruitments of trunk muscles during trunk exercises using the DWI.

Methods:
Nine healthy men (age, 26.3 ± 3.3 years; height, 171.1 ± 5.5 cm; weight, 62.1 ± 6.4 kg) participated in this study and all of them provided written informed consent before participation. This study was reviewed and approved by the Ethical Committee at the Waseda University. Participants performed five different types of trunk exercises: the front bridge supported by hands and knees (hand-knee), front bridge supported by forearms and knees (elbow-knee), front bridge supported by forearm and toe (elbow-toe), right side bridge, and knee raise. All participants performed one exercise out of these exercises per day, and carried out all exercises at intervals of one day or more. The order of these exercises was randomly assigned to each participant.

The axial diffusion-weighted images of the trunk were obtained before and immediately after each trunk exercise using 1.5-tesla MR system with 8-channel body array coil. The slice position was set at the midpoint of the intervertebral disk of L3-L4 as a point of reference. The b-value was set to 700 s/mm\textsuperscript{2} in order to exclude the effect of perfusion as possible for the calculation of ADC values. The ADC values of the right and left rectus abdominis, lateral abdominal muscles, quadratus lumborum and psoas major were calculated. A 2-way ANOVA was used to compare the ADC value between pre and post and among exercises.

Results:
The ADC value of the right side psoas major after the elbow-toe demonstrated the largest change (14.0%) and was significantly higher than that of the hand-knee, elbow-knee, and side bridge (p<0.05). For the quadratus lumborum, the ADC value of the right side increased significantly after the side bridge (14.8%). Also compared to other exercises, the ADC value of the right quadratus lumborum after the side bridge was significantly higher (p<0.05). The ADC value of the RA significantly increased after the elbow-toe and knee raise (p<0.05), and that of lateral abdominal muscles increased after the elbow-toe, knee raise and side bridge (p<0.05).

Discussion:
The ADC value of the right psoas major showed the substantial increase after the elbow-toe. During the elbow-toe exercise, participants supported their body by the right leg and left forearm. Thus, psoas major functions as a flexor of the hip during the elbow-toe. Previous studies using EMG reported that the activity of the rectus abdominis, external oblique, and transversus abdominis was high during the elbow-toe. In this study, the RA and lateral abdominal muscles showed significant increment of the ADC value, and these results agreed with the previous studies.

Previous study reported that the activity of the external oblique and transversus abdominis was large during the side bridge. Although the ADC value of the lateral abdominal muscles increased significantly between the pre and post in this study, the largest change of the ADC value was found in the quadratus lumborum. Thus, this result suggested that the quadratus lumborum greatly contributed to the control of the lateral flexion of the trunk.

Significance:
Results of this study suggested the possibility that the elbow-toe and side bridge are effective to enhance the function of the psoas major and quadratus lumborum, respectively.

Figure 1: The ADC maps before and after the front bridge supported by the forearm and toe (raised the right arm and left leg) and the right side bridge.