Muscle functional magnetic resonance imaging of the trunk

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Introduction

Exercise induced muscle activity is essential in sports medicine and rehabilitation medicine, especially the trunk muscle. Magnetic resonance imaging (MRI) can evaluate activity of the muscle; transverse relaxation time (T2) of exercised muscle increases compared to that of the rest muscle [1]. Akima et al. proposed the muscle functional magnetic resonance imaging (mfMRI) [2, 3] which visualized muscle activity with enhanced activated muscle. However, for calculating T2, the mfMRI using the spin echo (SE) sequence requires minutes of the acquisition time. And the body parts of the mfMRI were limited to the limbs. We proposed and verified the feasibility of mfMRI using ultrafast imaging (fast-acquired mfMRI: fast-mfMRI) [4]. The purpose of this study is to evaluate the trunk muscle activity using fast-mfMRI.

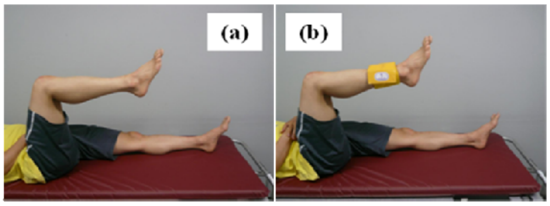

Figure 1: The exercise schema of exercise-1 (a), and exercise-2 (b) The exercises repeated 100 times flexion exercise from the position extending right thigh. During exercise-2, 1-kgs were loaded on right ankle.

Methods

The right psoas major muscles of seven male subjects (24.7±3.2 years, 171.2±9.8 cm, and 63.8±11.9 kg) on rest, after exercise-1 and after exercise-2 were scanned on a 1.5T whole body scanner with body-array coil. Two protocols were employed (a) true fast imaging with steady precession (TrueFISP) with TR 4.72 ms, TE 2.36 ms, matrix size 256×256, FA 50, BW 501 Hz/Px, acquisition time 12 seconds. (b) spin-echo echo planar imaging (SE-EPI) with TR 2000 ms, TE 30, 45, 60, 75 ms (4 echoes), matrix size 128×128 with interpolated into 256×256, FA 90, BW 1392 Hz/Px, acquisition time 2 seconds (for 1 echo). Slice thickness 10mm, FOV 400mm×400mm, NEX 1 were common factors. Subjects performed two exercises in lying supine on the bed (Figure 1). In exercise-1, the subject exercised 100 times of 90-degrees hip and knee flexion. In exercise-2 the subject wore 1-kg load on right ankle and exercised. T2 images were calculated using mono-exponential linear least-squares of the SE-EPI images. The areas of activated muscle were subtracted from T2 image of after exercise-1 or 2 to T2 image of rest. To eliminate the bowel loop and to emphasize the activated areas, threshold processing was applied to the subtraction image. Then the fast-mfMRI was created by combining the threshold images with the TrueFISP images.

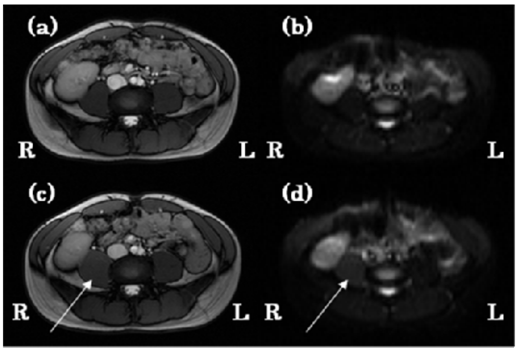

Figure 2: MR images of the trunk at rest (a, b) and after exercise-2(c, d). TrueFISP (a, c). SE-EPI (TE = 60 ms, b, d). Arrows indicates the activated right psoas major muscle.

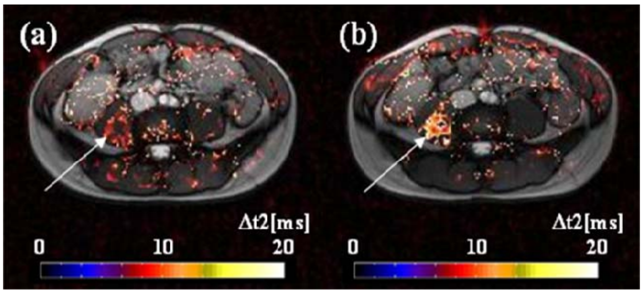

Figure 3: The fused image (fast-mfMRI) of after exercise-1 (a) and after exercise-2 (b). Color bar shows difference T2 (ΔT2). Arrows denote the activated right psoas major muscle.

Results and Discussion

Figure 2 shows the MR images in the trunk. The exercised right psoas major muscle indicates slight changes of signal intensity (SI), however, it is difficult to discrete the SI difference (Figs.2a, 2c). SE-EPI images indicate improved image contrast of the activated muscle (Fig.2d). Figure 3 shows the fusion images (fast-mfMRI) of exercise-1 and exercise-2. In the fast-mfMRI, the areas of activated right psoas major muscle were well enhanced and preserved morphological details. By implementing the threshold processing to T2 images, the background noise and the artifact from the bowel loop with high water content were eliminated. In addition, T2 can indicate the range of muscle functional. Compare Figure 3(b) to Figure 3(a), the right psoas major of after exercise-2 was more enhanced than after exercise-1. In morphological arrangement of the fast-mfMRI, there is no major difference between the anatomy image (TrueFISP) and the functional image (SE-EPI). The scan time of the fast-mfMRI is 22 seconds, enabling to acquire under a single breath hold.

Conclusion

In this study, we presented the fast-mfMRI demonstrating the functional information with detailed morphologies. One of the advantages of the fast-mfMRI is rapid scan time advantageous for the human trunk imaging.

Reference

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Acknowledgements

This work was supported by two agencies. One was Grant-in-Aid for Young Scientists (B) from the Ministry of Education, Culture, Sports, Science, and Technology (19700465). Another was Meiji Yasuda life foundation of health and welfare.