RECRUITMENT OF SPINAL MUSCLES IN STATIC POSTURES.

J. R. Meakin[1], S. I. Semple[1], T. W. Redpath[1], R. M. Aspden[2], and F. J. Gilbert[1]
[1]Radiology, University of Aberdeen, Aberdeen, United Kingdom, [2]Orthopaedics, University of Aberdeen, Aberdeen, United Kingdom

Introduction

The T2 relaxation time of skeletal muscle is known to increase as a result of exercise [1] and thus provides a useful method for detecting muscle recruitment. It is especially useful for investigating the muscles of the lower spine since the conventional method of EMG using surface electrodes cannot easily differentiate between the various muscles that are arranged in overlapping layers. EMG using needle electrodes solves this problem, but is invasive. Previous studies have concentrated on using T2 relaxation time, measured using MRI, to determine the effects of dynamic exercise [2]. In this study we have investigated the feasibility of measuring muscle recruitment after static exercise. This has applications in understanding how the spine achieves postural control.

Methods

Six volunteers (2 female, 4 male), aged between 30 and 40 years, were scanned before and after a static exercise. The exercise consisted of standing in a flexed posture for 10 minutes (or until fatigued) whilst holding 8 kg of weight in both hands. The flexed posture was defined by the subject's lower back making an angle of 30 degrees with respect to the vertical. The angle was checked periodically during the exercise using a liquid pendulum inclinometer and the posture of the subject adjusted if required.

Scanning was performed using a General Electric 1.5 tesla CVi/NVi scanner (Waukesha, USA). A four-echo spin echo imaging sequence was used with TR = 1600 ms and TE = 14, 28, 42 and 56 ms. Axial slices with a thickness of 8 mm and spaced by 11 mm were acquired in the lumbar region. Images were acquired over a 34 cm field of view using a 256 by 160 matrix. To minimise breathing artefacts in the spinal region, the phase direction was set to run from right to left.

IDL version 6.0 (ITT Visual Information Solutions, Boulder, CA) was used to calculate maps of T2 relaxation times. The T2 values were calculated from the four echo images on a pixel-by-pixel basis by regressing the signal intensity on the echo time and calculating the negative reciprocal of slope. Regions of interest were then drawn within the spinal muscles (right and left hand sides) using ImageJ 1.34s (NIH, USA) and the mean T2 value determined.

Results

Four of the subjects were able to hold the 8 kg weight for 10 minutes; two of the subjects were only able to manage 9 minutes. All subjects reported that their back muscles were tired by the exercise; two subjects noted that they felt more tired on one side than the other. Figure 1 shows a selection of the T2 maps calculated for one subject. This demonstrates the difference in the muscle activity, both before and after exercise, and between the left and right hand sides of the spine. The T2 values before exercise are shown for each the six subjects in Figure 2. A significant increase in T2 was found at the level of L2 and L5 (Figure 3).

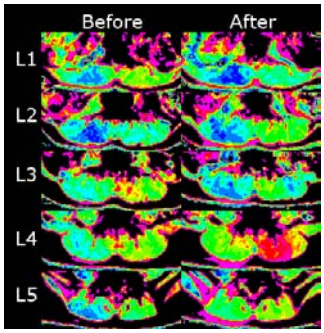

Figure 1. *T2 maps from top (L1) to bottom (L5) of lumbar region. Blue = low T2, red = high T2.*

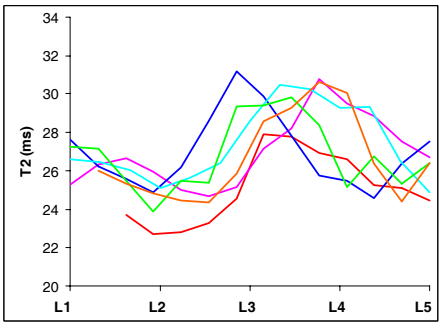

Figure 2. *T2 values before exercise for all six subjects (left and right hand sides of spine pooled).*

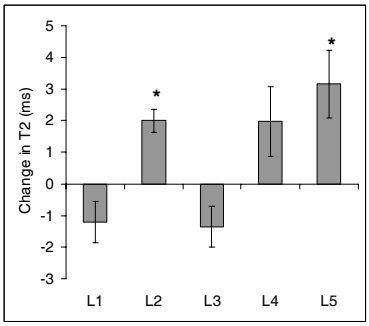

Figure 3. *Mean change in T2 after exercise. Error bars denote standard error.* ** P < 0.05*

Discussion and conclusions

The T2 values before exercise were found to vary across the lumbar spine. The pattern of variation, which was similar in all six subjects (Figure 2), may reflect normal muscle tone. The change in T2 after exercise indicated that the lumbar spinal muscles were not uniformly recruited, and that the greatest recruitment occurred at the lower lumbar levels. The results also showed that some subjects preferentially used the muscles on one side of their spine (Figure 1); this may have implications for muscle overload.

This pilot study demonstrated that significant increases in T2 can be measured in the spinal muscles after static exercise. The method has potential applications in helping us to understand more about the mechanical function of the normal spine, such as the relationship between posture and muscle recruitment and how this affects the forces in the spine. The method has advantages over EMG in that it provides good spatial resolution whilst being non-invasive.

References

1. Patten C, Meyer RA & Fleckenstein JL (2003) T2 mapping of muscle. Seminars in musculoskeletal radiology, 7, 297-305.
2. Mayer JM, Graves JE, Clark BC, Formikell M & Ploutz-Snyder LL (2005) The use of magnetic resonance imaging to evaluate lumbar muscle activity during trunk extension exercise at varying intensities. Spine, 30, 2556-2563.