Analysis of fat content in multifidus muscle with chronic low back pain using MR spectroscopy

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Aims and objectives

Low back pain (LBP), with an approximate lifetime prevalence of 80%, is one of the most common reasons for health consultations and the most common cause of job-related disability in developed countries, leading to high social and health-related expenses [1]. LBP can be caused by a variety of problems in any part of the complex, interconnected network of spinal muscles, nerves, bones, discs, or tendons in the lumbar spine.

The trunk muscles, erector spinal and posterior paraspinal have been reported to be involved in the etiology of LBP [2]. The multifidus muscle (Mm) is responsible for providing two-thirds of the spinal segment stability and plays an important role in the functioning of the trunk as well [3].

Previous imaging studies have examined the relationship between LBP and fat degeneration in the paraspinal muscles [4-6]. Moreover, various studies have reported the association between obesity and lipid metabolism as well as fat degeneration in Mm of patients with LBP [6, 7]. Diagnostic imaging techniques such as ultrasonography, computed tomography, and magnetic resonance imaging (MRI) are often used to assess fat degeneration in muscles [4, 5]. Among the MRI techniques, the multipoint Dixon technique [8], also known as magnetic resonance spectroscopy (MRS) [7, 9], has been used by previous studies. The MRS analysis of muscle physiology has been used in fields, such as sports medicine enabling detailed analyses of muscular fat mass [10-12], such as recording the presence of intramyocellular lipids (IMCL) and extramyocellular lipids (EMCL), which, in turn, has helped clarify the relationship between lipid metabolism and insulin resistance [13, 14]. Although some reports based on the relationship between fat degeneration in Mm and LBP have been published, the association of IMCL and EMCL with LBP still remains unclear.

The aim of the present study was to analyze IMCL and EMCL in Mm using MRS in patients with LBP and in healthy volunteers and to investigate whether IMCL and EMCL could be an objective indicator of LBP.
Methods and materials

Study participants

The institutional review board approved this prospective and cross-sectional study, and written, informed consent was obtained from study participants. Fifteen patients (mean age 49.8 years ± 12.5 standard deviation, age range 22-66 years) with nonspecific chronic low back pain (CLBP) were prospectively included in the study, having met the following inclusion criteria: (a) LBP duration of ≥3 months; (b) no prior spinal surgery; (c) no systemic inflammatory disease; (d) no neurologic disorder; (e) no acute trauma, neoplasm, or infection; and (f) no scoliosis. All patients underwent routine diagnostic MR imaging of the lumbar spine before undergoing imaging for the study. Next, 15 healthy volunteers known to be working normally, with no history of prior spinal surgery or LBP and in the same age range as patients with CLBP were recruited (mean age 44.0 years ± 12.8 standard deviation, age range 28-65 years). Body mass index (BMI) as an indicator of obesity was also measured.

MR imaging protocol

The Signa HDx 1.5T MRI system (GE Healthcare, Milwaukee, WI, USA) with a spine coil was used to obtain T2-weighted sagittal and transverse MR images. From these images, the proton MRS volume of interest at L4/5 for the right Mm was obtained (Fig. 1). Single-voxel point-resolved spectroscopy sequence was performed with following parameters: repetition time (TR), 2000 ms; echo time (TE), 35 ms; average number of signals, 64; voxel of interest, 15 × 15 × 15 mm³ (3.4 mL); and acquisition time, 164 s.

MR spectroscopic data and statistical analysis

The spectral data obtained were used to measure IMCL and EMCL using the LCModel software (Stephen Provencher, Inc., Oakville, Ontario, Canada) (Fig.2). BMI and IMCL and EMCL values in Mm were compared between patients with CLBP and healthy volunteers. The Mann-Whitney U test was used to test significance, which was set at a p-value < 0.05. All statistical analyses were performed with commercially available software (SPSS software, version 20.0; IBM, SPSS, Chicago, IL, USA).
Fig. 1: Volume of interest (VOI) for MRS measurements and multifidus muscle (Mm) derived from spectroscopy VOI for MRS measurements was set right Mm as indicated on the T1 weighted coronal and T2 weighted sagittal and transverse image at the intervertebral level L4 through L5.

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Fig. 2: MR spectrum of Mm was obtained from the positioning of the VOI and analyzed using LCModel software. The following metabolites are identified: IMCL (-CH$_2$) methylene protons at 1.3 ppm; EMCL (-CH$_2$) methylene protons at 1.5 ppm.
Results

The mean BMI of patients with CLBP and healthy volunteers was 24.3 $\pm$ 3.15 kg/m$^2$ and 22.9 $\pm$ 3.70 kg/m$^2$, respectively; the mean IMCL was 675.2 $\pm$ 308.9 mmol/L and 323.6 $\pm$ 197.6 mmol/L, respectively; and the mean EMCL was 2.57 $\pm$ 1.48 ($\times 10^3$) mmol/L and 1.77 $\pm$ 1.30 ($\times 10^3$) mmol/L, respectively. Thus, no significant difference was observed in BMI (Fig. 3), age, and gender between patients with CLBP and healthy volunteers (table). The IMCL of patients with CLBP was significantly higher than that of healthy volunteers ($p < 0.05$); however, no significant difference was observed for EMCL between the two. (Fig. 4).
Fig. 3: Comparison between CLBP patients and healthy volunteers in BMI No significant difference was observed in BMI between the two.

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Table 1: Distribution of the examinees with regard to the age and gender

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<table>
<thead>
<tr>
<th>Age (years)</th>
<th>CLBP patients</th>
<th>Healthy volunteers</th>
<th>P value</th>
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<tr>
<td>Mean±SD (95% CI)</td>
<td>49.8±12.5 (42.7-56.3)</td>
<td>44.0±12.8 (37.7-50.8)</td>
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</tr>
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</table>

SD Standard deviation, CI Confidence interval, BMI Body mass index
* Mann-Whitney U test
** Chi-square test

<table>
<thead>
<tr>
<th>Gender</th>
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<th>Healthy volunteers</th>
<th>P value</th>
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<td>Female</td>
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</tr>
</tbody>
</table>

Table 1: Distribution of the examinees with regard to the age and gender

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Fig. 4: Comparison between CLBP patients and healthy volunteers in IMCL and EMCL
(a) IMCL of patients with CLBP was significantly higher than that of healthy volunteers.
(b) No significant difference was observed for EMCL between the two.

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Conclusion

Several previous studies have reported an association between LBP and fat degeneration in the paraspinal muscles using various indicators and imaging techniques, all revealing an increase in fat degeneration [7]. However, majority of those studies [7-9] the fat-fraction of the multipoint Dixon technique to assess degeneration, whereas, studies using MRS comprehensively evaluated degeneration as the overall amount of fat content. In the present study, adipose tissue was distinguished from EMCL and IMCL as fat content in Mm, while the previous studies reported the increased fat content as IMCL in Mm of patients with CLBP.

Similar to the study by Mengiardi et al. [9] and Fisher et al. [7], we measured Mm at the L4/5 level because many pathological changes in Mm reportedly develop at this location [15, 16]. Moreover, Mms are inner muscles formed by type I fibers, which are rich in mitochondria exhibiting a high oxidative enzyme activity. In addition, the velocity of type I fiber contraction is comparatively slow, although the muscles are not easily fatigued. These fibers contain high levels of myoglobin and are, therefore, also known as red muscle fibers. They play an important role in maintaining homeostasis via producing and responding to cytokines through a mutually connected neural network located not only in the tissue adjacent to the skeletal muscle but also in the visceral adipose tissue [17, 18].

IMCL are stored inside skeletal muscle cells as small intramuscular lipid droplets that are located close to the mitochondria possibly associated with aerobic metabolism [10]. They serve as a rapidly available energy source for muscular fatty acid oxidation [19]. It has been reported that IMCL are associated with insulin resistance, and elevated IMCL levels have been observed in patients with type 2 diabetes [19, 20]. Because of the observed association between IMCL and LBP, it is possible that mitochondrial activity in Mm and other muscles is reduced, leading to accumulation of IMCL in patients with CLB, regardless of the etiology. These findings, together with those of the present study indicate that exercise therapy to accelerate mitochondrial activity and diet therapy to control additional adipose tissue accumulation, caused by excessive weight, are effective measures to reduce or eliminate nonspecific CLBP.

The present study had several limitations that should be addressed. First, the number of subjects included in the study was small. We needed to match the BMI and age of patients with CLBP to those of healthy volunteers, as the fat content in muscles correlates with this. However, it was difficult for us to obtain enough BMI- and age-matched healthy volunteers. Second, the daily physical activity of subjects in the present study was not assessed. Hence, it is possible that daily activity associated-changes in IMCL occurred in our subjects. Finally, because the present study used a cross-sectional design, it is
unclear whether the increase in IMCL was the cause or the result of LBP. Therefore, future longitudinal studies are warranted to address these limitations.

The results of the present study suggest a relationship between IMCL in Mm and CLBP. The use of MRS is expected to become an effective objective indicator of LBP.
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References


[12] Bredella MA, Ghomi RH, Thomas BJ, Miller KK, Torriani M. Comparison of 3.0 T proton magnetic resonance spectroscopy short and long echo-time measures of


