Manual Therapy 15 (2010) 364–369

Contents lists available at ScienceDirect

Manual Therapy

journal homepage: www.elsevier.com/math

Original article

The effect of unilateral muscle pain on recruitment of the lumbar multifidus during automatic contraction. An experimental pain study

N. Dickx [a,*], B. Cagnie [a], T. Parlevliet [b], A. Lavens [a], L. Danneels [a]

[a] Department of Rehabilitation Sciences and Physical Therapy, Faculty of Medicine, Ghent University, Belgium
[b] Department of Physical Medicine and Orthopaedic Surgery, Faculty of Medicine, Ghent University, Belgium

ARTICLE INFO

Article history:
Received 19 August 2009
Received in revised form
1 February 2010
Accepted 8 February 2010

Keywords:
Experimental pain
Multifidus muscle
Unilateral low back pain
Dynamic ultrasound imaging

ABSTRACT

Changes in control of the multifidus muscle are a likely contributor to low back pain (LBP), however, the underlying mechanisms of these changes are not well understood. To date it remains uncertain if pain has a selective effect on the multifidus muscles, in line with the observations of the selective changes in structure in acute LBP, or a more generalized effect.

The objective of this study is to help to elucidate whether acute unilateral muscle pain alters the activation of the multifidus specific at the level and side of the pain or has a more widespread effect.

An experimental pain protocol using hypertonic saline was applied to induce unilateral low back muscle pain. Automatic activity of the multifidus muscle during arm lifts was evaluated with dynamic ultrasound measurement, by assessing muscle thickness change during contraction. Multifidus activity of 15 healthy subjects was compared in a non-pain and in a pain condition, at different spinal levels (L3–L4–L5) and at both body sides.

Unilateral induced pain at one segmental level reduced muscle thickness increase during contraction, at both body sides and at different lumbar levels.

These results do suggest that unilateral pain may have a more widespread effect on multifidus muscle recruitment, affecting the left and right muscles, at different lumbar levels.

1. Introduction

Recent research has established an important role for muscle impairment within the pathology of low back pain (LBP). Changes in structure and function have been found in different trunk muscles and in all stages of LBP: acute, recurrent as well as chronic LBP. Many trunk muscles are required for control and stability of the spine, however, deep intrinsic muscles are critical for segmental stabilization of the spine (Panjabi, 1992).

It has been proven that the lumbar multifidus is a crucial stabilisator of the spine as the muscle is responsible for more than two-thirds of the lumbar segmental stiffness (Wilke et al., 1995). It is assumed that impairment of this muscle is a contributing factor in the development and maintenance of LBP. Many studies provide evidence for altered neuromotor control (i.e. delayed or reduced activity) as well as changed structure (i.e. reduced CSA (cross sectional area) and increased fat) of the multifidus in patients (Lindgren et al., 1993; Hides et al., 1994; Leinonen et al., 2001; Hodges and Moseley, 2003; van Dieen et al., 2003; Barker et al., 2004).

In 1994, Hides et al. published a study which demonstrated unilateral reduction in CSA of the multifidus in patients with acute unilateral LBP (Hides et al., 1994). Moreover, the muscle was affected only at the lumbar level of symptoms. Since then, other studies support the finding that changes in the multifidus are selective and therefore restricted to the side and level of symptoms (Barker et al., 2004; Macdonald et al., 2009). However, other LBP studies provide evidence of bilateral and more generalized changes, even in unilateral LBP (Kader et al., 2000; Dickx et al., 2008). The underlying mechanisms of these changes are not well understood. The question rises if acute unilateral pain only influences the multifidus at the level and side of the pain or has a more generalized effect. Studying this issue can gain more insight in the crucial role of pain within the complex pathology of LBP.

A method to target this question is investigation of the isolated contribution of pain on motor control. Different experimental models are available, of which the saline-model is commonly used in motor control studies (Arendt-Nielsen et al., 1996; Zedka et al., 1999; Hodges and Moseley, 2003; Hodges et al., 2003a). Using this model, the cause–effect relationship of pain on motor control can be examined. In addition, this set-up provides information of

* Corresponding author. Ghent University, Dept. of Rehabilitation Sciences and Physiotherapy, Campus Heymans (UZ) 3B3, De Pintelaan 185, 9000 Ghent, Belgium. Tel.: +32 9 332 58 06; fax: +32 9 332 38 11.
E-mail address: nele.dickx@ugent.be (N. Dickx).

1356-689X/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.math.2010.02.002

the non-pain and the pain condition within one subject, which is very important regarding the high variability in neuromotor control between subjects.

Usually electromyography (EMG) is used to investigate muscle activity, however, the deep multifidus muscles require intramuscular recording (Stokes et al., 2003). This invasive technique may provoke pain and thus interaction with our experimental unilateral pain model. An alternative non-invasive approach, is the indirect measurement of activity with dynamic ultrasound (US) during muscle contraction. It has been shown that increase in muscle thickness and more specific increase in multifidus thickness during low load contraction correlates with EMG activity (Hodges et al., 2003b; Kiesel et al., 2007). Recent studies have demonstrated that this technique is reliable and valid (Hides et al., 1995; Kiesel et al., 2007; Stokes et al., 2007; Wallwork et al., 2007).

The present experiment is based on a study of Kiesel et al. who investigated the effect of experimentally induced pain on lumbar multifidus activation during an arm lifting task (Kiesel et al., 2008). During this task, the multifidus muscle is recruited automatically, which is important for stabilization of the spine. They found that activation of the multifidus was reduced, at the level and the side of the pain induction. However, an important aspect of the study is that the multifidus was investigated only at one vertebral level and at one side (the level and the side of the pain induction), providing no information about the pattern of changes in the multifidus muscle. Therefore, the purpose of the current study is to investigate whether acute unilateral muscle pain alters the automatic activation of the multifidus selectively (at the level and side of the pain) or more generalized (at both sides and throughout different lumbar levels).

2. Methods

2.1. Subjects

Fifteen healthy subjects (6 male–9 female) volunteered for this study. Their mean age, height, and weight was 24 (±2) years, 172 (±9) cm, and 68 (±15) kg, respectively. Potential subjects were excluded from participation if they had any past or current back pain. All procedures were approved by the Ghent University Ethics Committee and each volunteer signed a written informed consent.

2.2. Ultrasound imaging

Subjects were positioned prone on the examination table with pillows under the abdomen to minimize the lumbar lordosis. An inclinometer ensured that the lumbar curve was less then 10° (Stokes et al., 2005; Kiesel et al., 2007; Wallwork et al., 2007).

An upper extremity lifting task was used to automatically contract the multifidus muscle (Hodges et al., 2003a). Subjects were positioned with their left arm in 140° abduction with the elbow slightly flexed, while the right arm stayed close to the subjects body. In the left hand, subjects held a weight of 0.5 kg (Kiesel et al., 2007). They were instructed to lift their arm 5–8 cm from the table and holding this position for 3 s. They were also reminded to fully relax their muscles in between the subsequent arm lifting tasks.

Ultrasound imaging was conducted using an Esaote Mylab 25 scanner, with a 5 MHz (70 mm footprint) curvilinear transducer. The left and right multifidus muscles were evaluated at three different lumbar levels L3–L4, L4–L5 and L5–S1.

Spinous processes L5, L4 and L3 were marked on the subjects skin as reference points. The location of these marks was confirmed using US, by visualizing the spinous processes relative to the sacrum.

To visualize the multifidus in the parasagital plane, the transducer was placed on the spinous processes and then moved lateral allowing visualization of the zygapophyseal joints, multifidus muscle and thoracolumbar fascia. At this scan point, the thickness of the multifidus can be easily evaluated (Wallwork et al., 2007).

To evaluate the thickness of the multifidus at rest and during contraction, a film of 10 s was obtained, allowing visualization of the relaxed muscle followed by the automatic contraction during arm lifting. During contraction, the multifidus swells and thickens and the muscle fibers change direction, which is recorded on the film (Stokes et al., 2007; Wallwork et al., 2007).

Of each film, two images of the multifidus were selected: 1) image of relaxed multifidus and 2) image of contracted multifidus. The film allowed us to choose the image in which the multifidus has reached maximal contraction.

Image selection, as well as the multifidus thickness measurement, was assessed on the Esaote Mylab 25 device. The multifidus thickness was measured using on-screen calipers placed on the outside edge of the muscle borders. The thickness of the multifidus was determined between two landmarks; the zygapophyseal joint and the thoracolumbar fascia, which are both echogenic on the US image (Kiesel et al., 2007; Stokes et al., 2007; Wallwork et al., 2007). This ultrasound imaging procedure was performed twice: once in the non-pain or control condition and once during induced pain (Fig. 1).

2.3. Experimentally induced pain

After completion of the US scanning during the control condition, subjects remained positioned on the examination table. Pain was induced using a standard procedure in experimental research: 1.5 ml hypertonic saline (5%) was injected into the right longissimus muscle (Arendt-Nielsen et al., 1996). The injection site was 5 cm lateral to the L4 spinous process, at a depth of 2.5 cm.

Before injection, the subject rated their fear of the induced pain between 0 (no fear) and 10 (extremely fearful) on a 100-mm visual analog scale (VAS) (Lamoth et al., 2004; Dickx et al., 2008).

After the pain induction, pain intensity was verbally rated from 0 (no pain) to 10 (very painful), analog with the VAS. If a subject reported a pain score below 4/10, an additional 0.5 ml saline was injected (Hodges et al., 2003a). Pain was evaluated three times during the experiment: 1) at the beginning of the US imaging 2) after completion of one body side, before changing the transducer to the other side of the body and 3) immediately after US imaging.

2.4. Statistical analysis

Analysis was performed using the SPSS statistical software (version 17.0).

The intra- and inter-tester reliability of the measurements was established in a pilot study performed on respectively 6 and 15 subjects. Intra- and inter-tester reliability was assessed with single measures intraclass correlation coefficients [$ICC_{1,1}$ and $ICC_{2,1}$].

Descriptive statistics (mean and standard deviation) were calculated for the thickness during rest and activity (cm) and thickness change (%) of the multifidus. Thickness change is defined as [(activity − rest)/rest * 100] (Kiesel et al., 2007, 2008; Wallwork et al., 2008).

A paired T test was used to compare the thickness (cm) at rest in the pain condition compared to the control condition.

For the investigation of the effect of pain on multifidus activity at 3 different lumbar levels and both body sides, thickness changes (%) were compared. A general linear model with repeated measures ($2 \times 3 \times 2$ Analysis of Variance (ANOVA)) was used and the within-subjects factors for the model are defined as; condition (control and pain), level (L3, L4 and L5), and side of body (left and right).