Location of injury site in chronic low back pain patients: an electromyographic and mechanomyographic analysis

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CHAPTER 1

INTRODUCTION

1.1. Background

In the western world, low back pain (LBP) is a common source of musculoskeletal disability now affecting 70-80% of adults at some stage of their lives (Graves et al. 1990, Helewa et al. 1999). LBP is the fifth most common reason for patients to visit their physicians (Hart et al. 1995). Ninety percent of acute (onset of injury less than three months) LBP patients recover within one month of the first onset of symptoms (Leggett et al. 1999). However the remaining 10% of LBP sufferers have chronic low LBP (CLBP) (symptoms more than six months) and disproportionately account for up to 85% of medical costs (US$38- and US$50- billion annually) associated with spinal disease in America (Frymoyer and Durrett 1997, Loisel et al. 1997). Although most patients recover from LBP within one month (Coste et al. 1994), 25-50% of those patients will suffer from additional episodes of LBP during the following year (Carey et al. 1999).

Disturbingly, patient disability caused by LBP is exacerbated given that 85% of LBP incidents are idiopathic and resistant to diagnosis of injury-site. Sub-optimal rehabilitation programs, with only moderate outcomes, may be the end result (Spitzer et al. 1987, White and Gordon 1982). The anatomy of the spine involves a complex system of ligaments, tendons and connective tissues which together support a series of segmental vertebrae each articulated by an intervertebral disc and two zygapophyseal joints. Injury to any part of this structure, that has a neural innervation, could lead to
LBP although there is some evidence to suspect that LBP most commonly results from
damage to the intervertebral discs (Donelson et al. 1997, Kayama et al. 1996, Kuslich
and Ulstrom 1991, O’Neill et al. 2002). This finding is supported by evidence that
following the application of stress to an intervertebral disc, either by injections through
discography, by probing during surgery or by electrothermal heating, common LBP
symptoms are produced. (Snook 2004). However, other evidence suggests that the
zygapophyseal- and sacroiliac- joints are also common injury sites, and sources of pain,
LBP patients (Bogduk 1980).

Unfortunately, even with the most modern and sophisticated diagnostic techniques,
most (85%) LBP patients still cannot be given an accurate diagnosis of the anatomical
injury-site responsible for their LBP. In such instances, patients have been classified as
having a generalized, unidentifiable diagnosis, non-specific LBP condition (Deyo and
Weinstein 2001, Nachemson and Vingard 2000). One factor which inhibits accurate
injury-site diagnosis is that LBP can manifest itself in several different ways through;
localized pain by which the patient experience tenderness or discomfort upon palpation;
diffuse pain whereby pain originates from deep tissue layers and spreads over several
dermatomes; radicular pain cased by irritation of a nerve root and referred pain
perceived in the lower back but caused by inflammation elsewhere often to the kidneys
or lower abdomen (Frey 1998).

As mentioned above, the time course associated with LBP shows an initial onset of
symptoms, to about 12 weeks post injury, being termed the “acute” phase, an episode of
three to six months being termed “sub acute” and any period after the sub acute phase
being termed “chronic” LBP (CLBP). Acute LBP, which commonly does not extend into the lower limb, is most frequently caused by a joint sprain or muscle tear usually occurring within 24 hours of a period of overuse of the back muscles. This type of pain is often localized with many patients showing instances of muscle spasms or soreness upon palpation (Frey 1998). In contrast, CLBP is an indiscriminate term which is associated with several underlying pathologies including zygapophyseal joint injury, intervertebral disc injury, and sacroiliac joint injury (Bogduk and McGuirk 2002).

Current diagnosis of injury-site in CLBP patients is often inconclusive even with the use of sophisticated and costly imaging techniques such as magnetic resonance imaging (MRI) (Indahl 2004). Problematically, the appearance of anatomical abnormalities on an MRI scan is not necessarily associated with LBP. For example, Jensen and co-workers (Jensen et al. 1994) have shown that 52% of asymptomatic subjects had a disc bulge, 27 percent had a disc protrusion and 1 percent had a disc extrusion at one vertebral level while 38% of subjects had an abnormality at more than one vertebral level. These researchers have concluded that anatomical irregularities, displayed by MRI, may only be coincidental in relation to LBP. Other diagnostic techniques, like discography followed by computed tomography (CT) or anaesthetic double needle blocks, have been shown to be useful and moderately reliable tools for injury-site site identification in LBP patients although the invasive nature of these techniques precludes them from non-hospital-based in-clinic applications (Dreyfuss et al. 1996, Maigne et al. 1996, Schwarzer et al. 1995). Similarly, CT-discography has been shown to be more sensitive than MRI to detect the early stages of disc degeneration although the relationship between such changes and LBP is yet to be fully substantiated (Bernard
Even with advanced and invasive diagnostic techniques, the anatomical origins of LBP often remains undiagnosed which potentially decreases the effectiveness of musculoskeletal rehabilitation programs, reduces positive outcomes and often changes the focus of such programs from injury rehabilitation to pain modulation (Indahl 2004).

What is required now is a diagnostic technique, for anatomical injury-site identification in CLBP patients, which is accurate, in-expensive and simple enough to utilise within a clinical environment. The diagnostic technique investigated here utilized a clinically-proven surface electromyographic (sEMG) technique, which assess neuromotor control, with a laser-based mechanomyographic (MMG) technique, which is a novel approach to measure changes in muscle contractile properties (e.g. contraction speed) which occur as a result of injury and/or disease.

It would be hoped that this study may lead to the development of an in-clinic diagnostic tool which may quickly, and accurately, determine injury-site in CLBP patients, facilitate the design of optimal rehabilitation programs, and improving rehabilitation outcomes.

1.2. **Aim and Hypothesis**

The primary aim of this thesis was to determine if anatomical injury site in CLBP patients can be identified by two complementary non-invasive diagnostic techniques, surface electromyography (sEMG) and mechanomyography (MMG). The application of these techniques to injury-site identification is based upon the hypothesis that muscle tissues surrounding an injured joint are physiologically distinct from those surrounding
“healthy” joints. Such changes in muscle physiology, associated with underlying joint pathology, may include alterations in muscle fibre type composition and number with a corresponding change in the muscle’s speed of contraction and its pattern of neuromotor control. These injury-induced changes in muscle function should be readily detected, at least in superficial muscles, by simple kinesiological techniques such as sEMG and/or MMG.

The secondary aims of this thesis were to determine:

(1) if the stoop-lift was a useful means of contrasting the activity of back muscles in healthy and CLBP subjects,

(2) the validity of the MMG technique to assess muscle contractile properties both in vivo and in vitro,

(3) whether the MMG technique can differentiate between individual muscle segment contractile properties, and

(4) whether the MMG technique is sensitive to changes in muscle contractile properties induced by applied physiological stress (muscle fatigue).

It was hypothesis that:

(1) muscle tissues surrounding an injured joint are physiologically distinct from those surrounding a “healthy” joint,

(2) a combined MMG and sEMG technique will accurately locate injury site in CLBP patients,

(3) the stoop-lift would be a valid means of differentiating between the back muscle function of a healthy control and a CLBP group of subjects,
(4) the MMG and sEMG technique are reliable and valid tools for the assessment of muscle contractile properties around healthy and injured zygapophyseal joints.

(5) the MMG technique will characterise differences in contractile properties of muscle segments, and

(6) the MMG technique will be sensitive to changes in muscle contractile properties due to applied physiological stress (fatigue).

The work detailed in this thesis describes the outcomes of six experimental studies. Chapters 4 to 7 provide data regarding the applicability of the sEMG and MMG techniques to characterise muscle contractile properties in both human and rat models. Based upon the outcomes of this work, Chapters 8 and 9 detail experiments designed to determine whether the combined sEMG and MMG diagnostic technique was able to accurately locate injury-site in a group of diagnosed CLBP patients.