Journal of Electromyography and Kinesiology 25 (2015) 919–927

Contents lists available at ScienceDirect

Journal of Electromyography and Kinesiology

journal homepage: www.elsevier.com/locate/jelekin

Pain intensity attenuates movement control of the lumbar spine in low back pain

C.M. Bauer [a,b,*], F.M. Rast [a,1], M.J. Ernst [a,1], S. Oetiker [a,1], A. Meichtry [a,1], J. Kool [a,1], S.M. Rissanen [c,3], J.H. Suni [d,4], M. Kankaanpää [b,e,2,5]

[a] Zurich University of Applied Sciences, Department of Health, Institute of Physiotherapy, Technikumstrasse 71, 8400 Winterthur, Switzerland
[b] University of Tampere, School of Medicine, Kalevantie 4, 33014 University of Tampere, Finland
[c] University of Eastern Finland, Department of Applied Physics, P.O. Box 1627, 70211 Kuopio, Finland
[d] UKK Institute for Health Promotion Research, Kaupinpuistonkatu 1, 33500 Tampere, Finland
[e] Pirkanmaa Hospital District, Physical and Rehabilitation Medicine Outpatient Clinic, Box 2000, 33521 Tampere, Finland

ARTICLE INFO

Article history:
Received 11 June 2015
Received in revised form 9 October 2015
Accepted 12 October 2015

Keywords:
Low back pain
Movement disorders
Biomechanical phenomena
Recurrence quantification analysis

ABSTRACT

Introduction: Pain intensity attenuates muscular activity, proprioception, and tactile acuity, with consequent changes of joint kinematics. People suffering from low back pain (LBP) frequently show movement control impairments of the lumbar spine in sagittal plane. This cross-sectional, observational study investigated if the intensity of LBP attenuates lumbar movement control. The hypothesis was that lumbar movement control becomes more limited with increased pain intensity. *Methods*: The effect of LBP intensity, measured with a numeric rating scale (NRS), on lumbar movement control was tested using three movement control tests. The lumbar range of motion (ROM), the ratio of lumbar and hip ROM as indicators of direction specific movement control, and the recurrence and determinism of repetitive lumbar movement patterns were assessed in ninety-four persons suffering from LBP of different intensity and measured with an inertial measurement unit system. Generalized linear models were fitted for each outcome. *Results*: Lumbar ROM (+0.03°, $p = 0.24$) and ratio of lumbar and hip ROM (0.01, $p = 0.84$) were unaffected by LBP intensity. Each one point increase on the NRS resulted in a decrease of recurrence and determinism of lumbar movement patterns (−3.11 to −0.06, $p \leqslant 0.05$). *Discussion*: Our results indicate changes in movement control in people suffering from LBP. Whether decreased recurrence and determinism of lumbar movement patterns are intensifiers of LBP intensity or a consequence thereof should be addressed in a future prospective study.

1. Introduction

Low back pain (LBP) is a common disorder with a lifetime prevalence as high as 84%, and a high probability of recurrence (Airaksinen et al., 2006). In many cases the cause of pain is never fully resolved (Hoy et al., 2010). LBP causes functional impairment in everyday life for a large proportion of the population and thus imposes large demands on healthcare and social systems (Dunn and Croft, 2004). Contemporary LBP classification systems propose that there is a large group of patients who present with movement control impairments (MCI), which are a relevant and provocative factor for ongoing pain (O'Sullivan, 2005). Typically 50% of patients with a MCI demonstrate changes in the sagittal plane (Vibe Fersum et al., 2009). These impairments may be the consequence of decreased tactile acuity (Luomajoki and Moseley, 2011), decreased ability to modulate task specific proprioceptive feedback (Claeys et al., 2011) or altered muscle recruitment patterns (Humphrey et al., 2005).

Tests of direction specific movement control (DSMC) assess the ability of a person to stabilize the lumbar spine during active movement of the hip and or knee. They are based on visual observation and use a dichotomous rating, have substantial reliability, and have been shown to differentiate between asymptomatic

* Corresponding author at: Zurich University of Applied Sciences, Department of Health, Institute of Physiotherapy, Technikumstrasse 71, 8400 Winterthur, Switzerland. Tel.: +41 58 934 71 71, +358 3 355 111; fax: +41 58 935 71 71.

E-mail addresses: christoph.bauer@zhaw.ch (C.M. Bauer), saara.rissanen@uef.fi (S.M. Rissanen), jaana.h.suni@uta.fi (J.H. Suni), markku.kankaanpaa@pshp.fi (M. Kankaanpää).

[1] Tel.: +41 58 934 71 71.
[2] Tel.: +358 3 355 111.
[3] Tel.: +358 40 3552370.
[4] Tel.: +358 3 282 9111.
[5] Tel.: +358 3 311 611.

http://dx.doi.org/10.1016/j.jelekin.2015.10.004
1050-6411/

persons and patients with LBP (Luomajoki et al., 2007, 2008). However, objective, quantitative data on the severity of MCI assessed by DSMC tests in people suffering from LBP are currently lacking. Repetitive movements (RM) can demonstrate changes in lumbar spine kinematics which are not observed when analyzing purely the range of motion or magnitude of MCI (Lamoth et al., 2006; Silfies et al., 2009). Less variable movement patterns of lumbar spine were observed in persons with chronic LBP when they repetitively picked up a box (Dideriksen et al., 2014) or performed repeated trunk movements (Asgari et al., 2015). Persons with chronic LBP also demonstrated less variable recruitment patterns of lumbar erector muscles during lifting tasks (Falla et al., 2014).

The effect of LBP on lumbar movement may be more pronounced in higher order kinematics (Aluko et al., 2013; Bourigua et al., 2014; Marras et al., 1993, 1995). Participants with chronic LBP showed smaller lumbar angular velocity and acceleration during a repeated trunk flexion–extension task, compared to pain free participants. These group differences were less pronounced when analyzing purely their angular displacement (Marras et al., 1995). Increased lumbar angular velocity and acceleration during lifting tasks had a greater odds ratio for future low back pain episodes when compared to changes in angular displacement (Marras et al., 1993). Chronic LBP patients showed lower angular velocity during trunk flexion at self-selected and fast movement speeds (Bourigua et al., 2014). Lumbar acceleration increased after a six weeks exercise intervention that reduced LBP intensity (Aluko et al., 2013).

Previous cross-sectional studies often do not report the relationship between LBP intensity and MCI, and do not consider that pain differently attenuates motor planning and diminishes proprioception, and that tactile acuity depends up on its intensity (Catley et al., 2014; Matre et al., 2002; Ervilha et al., 2004). The purpose of this study is to investigate the effect of LBP intensity on MCI using two DSMC tests, and one RM test. The emphasis is on reduced control of active movement (Luomajoki et al., 2008; O'Sullivan, 2005) and on repetitive task movement control (Dideriksen et al., 2014). It is hypothesized that lumbar movement control deteriorates with increased LBP intensity. Anthropometric factors such as age, gender, or body mass index (BMI) influence lumbar kinematics (Consmuller et al., 2012). Persons engaging in heavy manual labor have a higher risk of developing LBP (Hoozemans et al., 2002). These factors should be controlled for when investigating the relationship between lumbar kinematics and LBP.

2. Methods

2.1. Design

Cross-sectional, observational study.

2.2. Participants

Sixty-three participants with sub-acute or chronic LBP and 31 asymptomatic participants, aged between 18 and 65 years were recruited from physiotherapy practice, the university campus and through newspaper advertisements. Participants with LBP were included if their current episode of LBP persisted for four weeks or longer, and if they reported at least moderate disability, defined as an Oswestry-disability-index (ODI) >8% and a low level of psychosocial risk factors defined with less than four points on the subscale of the STarT Back screening tool (Mannion et al., 2006). Exclusion criteria were specific LBP, vertigo or disturbance of the equilibrium, systemic diseases (diabetes, tumours), pain in other areas of the body (neck, head, thoracic spine, or arms), complaints, injury, or surgery of the legs (hips to feet) within the last six months, medication affecting postural control (e.g. anti-depressants) and pregnancy. The exclusion criteria for asymptomatic participants were the same as for the LBP participants, and additionally no current LBP episodes or episodes during the preceding three months. The study was conducted according to the declaration of Helsinki, and approved by the local ethics committee (KEK-ZH-2011-0522). Participants provided their written informed consent.

2.3. Movement analysis

2.3.1. Sensor placement and data processing

Trunk movements were measured by an inertial measurement unit (IMU) system, with multiple IMUs placed above the right thigh, sacrum and at the level of L1, (Ernst et al., 2013; Schelldorfer et al., 2015) (Fig. 1). The IMU system has been shown to provide concurrently valid estimates of spinal kinematics (Bauer et al., 2015).

The sensors of the IMU system (ValedoMotion, Hocoma AG, Volketswil, Switzerland) include a tri-axial gyroscope, magnetometer, and accelerometer. Movement data were recorded with a sampling frequency of 200 Hz (Valedo®Research, Hocoma AG). The raw data from the IMUs were transformed into quaternions to prevent rotational singularities (Madgwick et al., 2010). Segmental kinematics were calculated using the tilt/twist formulation (Crawford et al., 1999) with sagittal and frontal planes defined by the global coordinate system. All outcome variables were derived from the flexion/extension angle, where flexion is positive and extension is negative. An angle of zero degrees is defined as

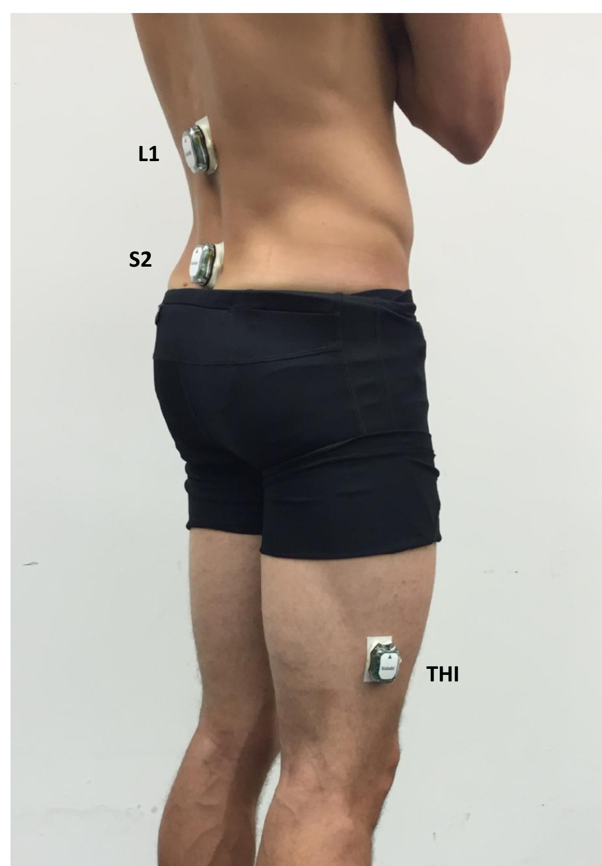

Fig. 1. Experimental setup: IMUs were placed on the right thigh (THI), and level of sacrum (S2), and L1 (L1).