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The effect of wearing a lumbar belt on biomechanical and psychological outcomes related to maximal flexion-extension motion and manual material handling

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ABSTRACT

Workers with low back pain (LBP) may benefit from wearing a lumbar belt (LB), but the biomechanical and psychological mechanisms involved are not fully understood. Two types of flexible LB (extensible and non-extensible) were compared to a control condition (no LB) regarding pain-related (pain, fear of pain and catastrophizing) and biomechanical (range of motion – ROM) outcomes related to two tasks: maximal trunk flexion-extension and manual material handling. Healthy controls and participants with LBP were tested. During both tasks, the two LBs reduced the lumbar ROM in participants with LBP in the same way as healthy controls. This was observed even at the beginning of the trunk flexion movement, allowing generalization to many work tasks, that is to say tasks performed with small or deep trunk flexion. The two LBs reduced pain, fear of pain and catastrophizing in subjects with LBP. That may help a gradual re-exposure to physical work activities (disability prevention perspective), or maintaining these activities (secondary prevention perspective), following a LBP episode.

1. Introduction

Despite evidence that wearing a lumbar belt (LB) is inefficient for the primary prevention of low back pain (LBP) (van Duijvenbode et al., 2011), there may be benefits in secondary prevention; but the insufficiency or low-quality of the current evidence prevents recommending its use in any subgroup workers with LBP at this moment (Chou et al., 2016; NICE, 2016). For example, wearing a LB sporadically (during pain flare-ups; when expecting development of LBP) have shown beneficial effects in workers attempting to stay at work despite current or recurrent LBP (Roelofs et al., 2007a). Moreover, a late return to work may further deteriorate the health of the worker (Rueda et al., 2012). Wearing a LB may provide the psychological support necessary to initiate a partial or complete return to work and thereafter, a sustained return to work. This would have to be understood by interveners, supervisors and co-workers at the workplace. The LB, however, must provide biomechanical support to ensure worker safety. As such, a study examining the impact of wearing a LB on biomechanical and pain-related psychological variables is warranted.

With regard to biomechanical mechanisms, wearing a LB has consistently been shown to reduce lumbar and trunk range of motion (ROM) in various loading and motion conditions, including maximal trunk flexion-extension (Meyer, 2000; Nimbarte et al., 2005; van Poppel et al., 2000). As the goal in these studies was to achieve maximal trunk flexion, the possibility that reduced lumbar ROM was, in part, explained by sensory feedback serving as a reminder for good postural hygiene was excluded. Consequently, reduced lumbar ROM was explained by the stiffening effect provided by the LBs to the trunk (Cholewicki et al., 1999b, 2010; Ivancic et al., 2002; Larivière et al., 2015; Lavender et al., 2000; McGill et al., 1994; Thomas et al., 1999). Earlier findings on healthy subjects found that wearing a LB reduced the lumbar contribution to trunk flexion in the first phases (near upright), but increased it in the final phases, near the maximal flexion posture (Larivière et al., 2014). This early restriction of lumbar spine movement during trunk flexion suggests that the use of a LB would have benefits not only during work requiring maximal trunk flexion, but also

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during work tasks requiring small trunk movements. These findings, however, must be extended to unconstrained functional tasks, such as manual material handling (MMH), to understand the effect of LB in daily activities where the trunk is only slightly to moderately flexed, and where the knees are also free to bend. While inter-joint coordination has already been studied during lifting (McGorry and Hsiang, 1999; Nimbarte et al., 2005), it is preferable to perform the constrained (trunk maximal flexion-extension - MFE) and unconstrained (MMH) task in the same subjects, allowing for better effect comparison. These findings must also be extended to subjects with LBP, since all previous research is based on healthy subjects.

With regard to pain-related psychological mechanisms, wearing a LB may produce immediate pain relief and reduce pain-related fears and catastrophizing. For the workers absent from work, this may increase self-efficacy, allowing a gradual exposure to physical work (disability prevention perspective) or the maintenance of these activities (secondary prevention perspective). This would be in line with a fear-avoidance model (Vlaeyen and Linton, 2000), more recently adapted to integrate the concept of self-efficacy (Woby et al., 2007). Interestingly, the immediate and long-term effects of wearing a LB on these pain-related psychological mechanisms have never been formally tested.

Two types of flexible LB, that provide adequate comfort and functionality for use at the workplace, are (1) extensible and (2) non-extensible belts. The extensible belts (EB) are more popular in the workplace, and more readily available. The non-extensible belts (NEB), which are flexible but not elastic, do not expand with the outward expansion of the abdomen that occurs during lumbar flexion. Non-extensible LB, therefore, may promote increased intra-abdominal pressures, which, in turn, may increase lumbar stiffness (Cholewicki et al., 1999a; Stokes et al., 2011). One study has shown more lumbar stiffness with a NEB than with an EB (Cholewicki et al., 2010), although another study showed no difference (Larivière et al., 2015). This question needs to be revisited not only in healthy individuals, but also in participants with LBP.

This first aim of this study was to assess the immediate effects of wearing two types of LB (EB and NEB) on segmental trunk ROM and coordination during trunk maximal flexion-extension and MMH tasks. A secondary aim was to assess pain-related variables (pain intensity, fear of pain, and pain catastrophizing) during these activities which are usually perceived as threatening for the low back. Biomechanical variables will be measured in healthy controls and participants with LBP while pain-related variables will be measured only in participants with LBP.

2. Materials and methods

2.1. Participants

Twenty healthy controls and 40 participants with LBP, aged 18 to 65 and equally divided by sex, participated in the experiments. Forty participants with LBP were recruited to allow subgroup analyses, but the corresponding results were not conclusive and will not be reported. The participants were recruited through newspaper advertisement and from physiotherapy clinics in Montreal, Quebec, Canada. General inclusion criteria were: mastery of French or English; being currently employed, or, for participants with LBP, having been employed before the current episode of LBP. The specific inclusion criteria for the LBP group were: lumbar or lumbosacral pain (with or without radicular pain) for at least 4 weeks (non-acute phase); no radicular pain below the knees. General exclusion criteria were: pelvic or spinal surgery; specific lumbar pathology (fracture, infection or tumor); scoliosis; systemic or degenerative disease; body mass index > 30 kg/m^2; high blood pressure (systolic > 140 mmHg and/or diastolic > 90 mmHg); history of neurological condition other than those related to back pain; anxiolytic medication, anticonvulsant or antidepressant; medication which can influence neuronal excitability (antispasmodic, anti-inflammatory and analgesic medications were accepted); sacroiliac pain as identified with five clinical tests (Laslett, 2008), and having a forensic conflict. Additional exclusion criteria for healthy controls were the presence of back pain in the last year, or having a history of back pain lasting more than a week. All participants were informed about the experimental protocol and potential risks, and signed written consent before participation. The ethics committee of the Center for Interdisciplinary Research in Rehabilitation of Greater Montreal (CRIR) approved the study and the consent form.

2.2. Lumbar belts

Two types of extensible and non-extensible LB were chosen by consultation with an orthotist, based on functionality of use at work (flexibility and comfort) as well as affordability and durability. Both types of LB consisted of two layers of straps, secured with Velcro material. Initial adjustment and placement of the LB was carried out with the inner layer, while the final tension was adjusted with the external layer, which was an elastic material for the extensible LB (EB) (model LumboLux, Hope Orthopedic) and non-extensible nylon straps for the non-extensible LB (NEB) (model 582, MBrace). The EB also allowed for insertion of dorsal and ventral panels that were not used in the present study. Both LBs are commercially available in seven lengths, with standard abdominal and dorsal heights of 6 and 10 inches, respectively. The 6-inch front, which is typical of most “low-profile” LBs on the market, is regarded as being less restrictive of trunk flexion.

Each LB was positioned on the trunk over a T-shirt when the participant was sitting, such that the lower edge of the LB covered the antero-superior iliac spines without touching the thighs. Before recording an experimental condition with a LB, the tension of the LB was adjusted with the participant in quiet standing. To do so, a FSR sensor (Force Sensing Resistor; Interlink Electronics; model FSR400) was attached on the skin between the lateral aspect of the left iliac crest and the 12th rib. Using this feedback system, the participant adjusted the LB tension to reach a pressure of 60 mmHg or 8.0 kPa.

2.3. Tasks and experimental conditions

All the participants, e.g. healthy controls and participants with LBP performed the tasks described here. A few practice trials were performed before each task. No participants with LBP left due to symptoms.

2.3.1. Maximal flexion-extension task (MFE)

Starting from the upright posture and following the pace of a metronome, the participants bent forward to the maximum possible flexion angle (4 s to flex), remained relaxed in that fully flexed posture (4 s to relax), returned to the upright posture (4 s to extend) and stood quietly (4 s to stand). The task was performed 5 times consecutively. The participants were instructed to keep the knees straight, to prevent activation of the abdominal muscles (not forcing flexion), and to keep the head fully flexed in order to minimize the cervical movement (Geisser et al., 2004; Watson et al., 1997).

2.3.2. Manual material handling task (MMH)

The participants were asked to move three boxes (plastic milk crates), one at a time, between two force-plates, and then return them to their original position (Fig. 1). The participants were instructed to complete each lifting (extension to full, upright posture) and lowering phase in the sagittal plane (perfect symmetry), before moving their feet to turn around and reposition their body. The whole task included six lifting and lowering movements. The participants were free to choose the movement pace, as well as the lifting/lowering technique, except that they had to grab the boxes by the handles placed 5 cm (symmetrically) from the bottom of the box. The boxes were 33 cm wide and