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Original article

The effect of within-session instruction on lumbopelvic motion during a lower limb movement in people with and people without low back pain

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ABSTRACT

The purpose of the current study was to examine how effectively people with and people without low back pain (LBP) modify lumbopelvic motion during a limb movement test. Nineteen subjects with LBP and 20 subjects without LBP participated. Kinematic data were collected while subjects performed active hip lateral rotation (HLR) in prone. Subjects completed trials (1) using their natural method (Natural condition) of performing HLR, and (2) following standardized instructions to modify lumbopelvic motion while performing HLR (Modified condition). Variables of interest included (1) the amount of HLR completed prior to the start of lumbopelvic motion, and (2) the maximum amount of lumbopelvic motion demonstrated during HLR. Compared to the Natural Condition, all subjects improved their performance during the Modified condition by (1) completing a greater amount of HLR prior to the start of lumbopelvic motion, and (2) demonstrating less lumbopelvic motion ($P < 0.01$ for all comparisons). There was a tendency for people without LBP to demonstrate a greater difference in maximal lumbopelvic rotation between the Natural and Modified conditions ($P = 0.07$). In conclusion, people are able to modify lumbopelvic motion following instruction. Further study is needed to determine if people without LBP improve lumbopelvic motion following instruction to a greater extent than people with LBP.

1. Introduction

Low back pain (LBP) is a musculoskeletal condition that affects up to 80% of the population at some point in their lifetime (Lawrence et al., 1998). Although as many as 90% of individuals who initially seek medical treatment for an acute episode of LBP stop seeking medical treatment within 3 months of the initial consultation, as many as 75% of these individuals state they are not fully recovered one year later (Croft et al., 1998). The economic and social impact of the persistent and recurrent course of LBP has led to the development and study of many diverse treatment options.

Despite the numerous studies that have been conducted, no treatment has been found to be consistently effective for alleviating the persistent symptoms and functional limitations associated with LBP. One proposal for the inconsistent findings is that previous treatments have not adequately addressed the potential importance of movements performed frequently across the day (Sahrmann, 2002). If movements are performed repeatedly across the day, then these movements could contribute to the often persistent and recurrent course of LBP.

Many of the activities frequently performed throughout the day involve limb movements. Limb movements are important in the examination of people with LBP because limb movements produce forces on the lumbopelvic region and, therefore, could induce movement of the lumbopelvic region. Repetitive lumbopelvic motion with limb movements could contribute to accumulation of lumbopelvic region tissue stress, microtrauma, and, eventually, LBP (McGill, 1997). Investigators have examined the effect of limb movements on the lumbopelvic region in people with and people without LBP. During active movements that involved the limbs, people with LBP demonstrated decreased trunk control (Mok et al., 2007) and different lumbopelvic movement patterns (Shum et al., 2005) compared to people without LBP.

Of interest to our work is how far a person can move the limb before the lumbopelvic region begins to move. How far the limb moves prior to the start of lumbopelvic motion is important because many daily activities are performed in the early to mid ranges of limb movements (Shum et al., 2005, 2007; Rose & Gamble, 2006; Bukowski, 2009). If the lumbopelvic region begins to move during the early to mid ranges of the limb movement, and

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the limb movement is performed frequently across the day, then there could be an increase in frequency of lumbopelvic motion across the day (Sahrmann, 2002). We previously have reported that (1) people with LBP demonstrate earlier lumbopelvic motion during active limb movements than people without LBP (Scholtes et al., 2009), and (2) people with LBP report a decrease in symptoms when the lumbopelvic region is manually restricted during a limb movement (Van Dillen et al., 2003, 2007).

Although modifying lumbopelvic motion during a limb movement has been found to be beneficial, the procedures previously used to modify the motion are limited. During the clinical examination, modification of lumbopelvic motion occurs through verbal instruction provided to the patient, coupled with manual stabilization provided by the clinician. This method eliminates lumbopelvic motion and decreases symptoms. Thus, prescribing an activity that reduces lumbopelvic motion during a limb movement as part of a home program may be beneficial. Successful performance of a limb movement as part of a home program however, would require the patient to be able to control movement of the lumbopelvic region independently, without manual assistance.

The purpose of the current study, therefore, was to examine how effectively people with and people without LBP independently modify lumbopelvic motion during an active limb movement test following standardized, within-session instruction. Hip lateral rotation (HLR) was examined in the current study because (1) it provokes symptoms in people with LBP (Van Dillen et al., 2001; Gombatto et al., 2006), and (2) lumbopelvic motion during HLR is different between people with and people without LBP (Scholtes et al., 2009). We hypothesized that, following instruction, all people would (1) complete a greater amount of HLR prior to the start of lumbopelvic motion, and (2) demonstrate less lumbopelvic motion during HLR. We also hypothesized that people without LBP would demonstrate greater improvements in both variables than people with LBP. The current study is important because it provides information about how quickly and how effectively people independently modify a movement pattern. This information may help guide a clinician to provide the most appropriate home program for a person with LBP or a different musculoskeletal pain condition.

2. Methods

2.1. Subjects

Nineteen subjects with LBP and 20 subjects without LBP participated in the study. Table 1 includes subject and LBP-related characteristics of the sample. Subjects were excluded from the study if they reported having (1) a height and weight consistent with a body mass index (BMI) greater than 30, (2) a hip or knee injury that limited activities of daily living, (3) a history of a spinal fracture or surgery, or (4) a diagnosis by a physician of a spinal deformity, systemic inflammatory condition, or other serious medical condition that could affect the ability to move (e.g., Parkinson's disease). Subjects were included in the LBP group if they reported chronic or recurrent LBP of more than 6 months (Von Korff, 1994). Subjects were excluded from the group without LBP if they reported any prior LBP episode that affected activities of daily living for more than 3 days or for which they sought medical or allied health intervention. Prior to participation in the study, all subjects provided informed consent approved by the Human Research Protection Office of Washington University School of Medicine.

2.2. Clinical measures

All subjects completed self-report questionnaires including a demographic and LBP history questionnaire and a Baecke Habitual Activity Questionnaire (Baecke et al., 1982). Subjects with LBP also completed (1) a verbal numeric pain rating scale (Jensen et al., 1994), (2) a modified Oswestry Disability Index (Fritz and Irrgang, 2001), and (3) a Fear Avoidance Beliefs Questionnaire (FABQ) (Waddell et al., 1993).

2.3. Laboratory measures

Subjects performed the test of active HLR in prone (Sahrmann, 2002). At the start of each trial, the tester manually supported the tested limb in a position of neutral femoral abduction/adduction, 5° of hip medial rotation, and 90° of knee flexion. The non-tested limb was positioned in full hip and knee extension. Prior to each trial, the subject was instructed to bring the foot in as far as possible (i.e., lateral rotation) and then return the foot to the start position. Prior to the first trial, the tester assisted the subject in understanding the desired direction of motion by manually rotating the hip a few degrees. All trials were performed on the right and left limbs separately. Subjects performed 5 trials using their natural movement pattern (Natural condition) and 10 trials following standardized instructions (Modified condition). Ten Modified trials were completed to assess whether greater improvement in performance occurred with repetition. Prior to each Modified trial, the tester provided verbal and tactile information that was intended to assist the subject in modifying lumbopelvic motion during HLR. The subjects were instructed verbally to contract the abdominal muscles and not allow the pelvis to rotate during HLR. While giving verbal instructions, the tester also provided tactile information to the abdominal muscles and posterior pelvis. Following each Natural or Modified trial, symptom response (increased, decreased, same) compared to the starting position, was assessed.

Kinematic data were collected using a 6-camera motion capture system (EVaRT, Motion Analysis Corporation, Santa Rosa, CA, USA). Reflective markers were placed on landmarks of the trunk, pelvis, and limbs to capture limb and lumbopelvic rotation during testing. Data were collected at a sampling rate of 60 Hz. The static resolution of the motion capture system was 1 mm per cubic meter.

2.4. Data processing

Angular displacement and velocity of movement for the lower leg and lumbopelvic region were calculated across time. Hip lateral rotation was indexed using the lower leg segment; the segment was defined by a vector from a marker superficial to the lateral malleolus to a marker superficial to the lateral knee joint line. Hip lateral rotation was calculated as a change in the angle of the lower leg segment relative to the initial position (Gombatto et al., 2006). Lumbopelvic rotation was indexed using a pelvic segment; the segment was defined by a vector between markers placed superficial to the posterior superior iliac spines. Lumbopelvic rotation was calculated as a change in angle of the pelvic segment relative to the initial position (Fig. 1).

Motion capture data were initially filtered using a 4th order, dual pass, butterworth filter with a cut-off frequency of 2.5 Hz. After this initial filtering, the start and end points of HLR and lumbopelvic rotation were determined and movement time was calculated. Because subjects were allowed to move at a self-selected speed, the raw data was then re-processed using a subject-specific cut-off frequency (fc_{ss}) to filter the data (Winter, 2005). The subject-specific cut-off frequency was calculated by taking the reciprocal of 15% of the period, $fc_{ss} = 1/(0.15 \times 2 \times \text{movement time})$ (Gombatto et al., 2006).

The start of HLR was defined as the point at which angular velocity exceeded 5% of the maximal angular velocity of the lower