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Do people with recurrent back pain constrain spinal motion during seated horizontal and downward reaching?

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ABSTRACT

Background: Although the effect of symptomatic back pain on functional movement has been investigated, changes to spinal movement patterns in essentially pain-free people with a history of recurrent back pain are largely unreported. Reaching activities, important for everyday and occupational function, often present problems to such people, but have not been considered in this population. The purpose of this study was to compare the amplitude and timing of spinal and hip motions during two, seated reaching activities in people with and without a history of recurrent low back pain (RLBP).
Methods: Spinal and hip motions during reaching downward and across the body, in both directions, were tracked using electromagnetic sensors. Analyses were conducted to explore the amplitudes, velocities and timings of 3D segmental movements and to compare controls with subjects with recurrent, but asymptomatic lumbar or lumbosacral pain.
Findings: We detected significant differences in the amplitude and timing of movement in the lower thoracic region, with the RLBP group restricting movement and demonstrating compensatory increased motion at the hip. The lumbar region displayed no significant between-group differences. The order in which the spinal segments achieved peak velocity in cross-reaching was reversed in RLBP compared to controls, with lumbar motion leading in controls and lagging in RLBP.
Interpretation: Subjects with a history of RLBP show a number of altered kinematic features during reaching activities which are not related to the presence or intensity of pain, but which suggest adaptive changes to movement control.

1. Introduction

The extent to which recurrent low back pain (RLBP) has an impact on the way in which people move is uncertain. Most studies into the impact of back pain on function have recruited subjects with current acute or chronic symptoms, thus altered movement patterns might be attributable to elicitation of, or guarding against, pain, or might reflect changes in the mechanics or control of spinal motion. It is not known to what extent symptomatic recovery from an episode of back pain leaves the individual with residual and persistent changes to their patterns of movement and whether these may predispose the person to further episodes.

Adaptive changes to trunk movement can arise from a number of sources. Soft tissues that have experienced trauma, or where extensibility has been constrained through spasm or splinting, may respond by becoming stiffer and shorter (Herbert and Balnave, 1993; Vattanasilp et al., 2000). Habitual changes to motor unit firing may alter muscle recruitment and control (Ferreira et al., 2004) and persistence or recurrence of pain may produce behavioural changes, including fear avoidance and catastrophization (Sturgeon and Zautra, 2013; Vlaeyen and Linton, 2012) and even reorganisation of the motor cortex (Tsao et al., 2008, 2011).

There is increasing evidence linking the presence or history of back pain to altered timing and coordination of spinal segments during functional activities (Lamoth et al., 2002; Silfies et al., 2009). Most investigations of spinal coordination have focused on lumbar control during walking and sitting-to-standing (Anders et al., 2005; Hsieh and Pringle, 1994; Shum et al., 2005a) with limited exploration of the impact of back pain on reaching tasks (Shum et al., 2005b). Seated reaching activities are, however, common in domestic and occupational settings and require mobility and control throughout the trunk. Thus they can be challenging for people with back pain.

Understanding the impact of repeated episodes of back pain on the way people move, particularly in the absence of significant pain, is important in developing a clearer rationale for intervention. Habituation to altered movement patterns may impede responsiveness

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to conventional therapy aimed at restoring function and therapy concentrating on pain relief may be missing an important dimension in the patterns of impairment. The extent to which recurrent back pain changes the synchrony and patterns of movement of the spine is unknown.

The purpose of this investigation was to explore the amplitude and timing of motion in the thoracic, lumbar and hip articulations during two reaching activities; across the body and simulating the pulling up of a sock while in a seated position. These activities were selected because they require substantial flexion, in one case with little requirement for out of plane motion (sock dressing) (Shum et al., 2005b) and in the other with a requirement for orthogonal motion (cross-reaching). Both tasks are functionally relevant and familiar to most people, thus likely to be carried out in a natural manner.

2. Methods

2.1. Study participants [Table 1]

20 healthy volunteers, (13 female; 7 male), and 20 volunteers (12 female; 8 male) with a history of recurrent, non-specific back pain were recruited. Recurrence was determined through participant recall of episodes of back pain of sufficient severity to require at least medication for pain control and which had lasted at least 24 h and was preceded and succeeded by periods of at least one month without back pain (de Vet et al., 2002). There were no significant age differences between groups either for males or females or for the cohorts as a whole ($P = 0.45$). All participants were assessed by a physiotherapist before testing. Participants were excluded from the control group if they had a history of back pain requiring medical attention or treatment and from both groups if they had any apparent neurological or orthopaedic disorders or previous surgery likely to interfere with movement. Simple anthropometric data were collected and, from those with RLBP, symptoms and history were assessed using the Roland-Morris Disability Questionnaire (Roland and Morris, 1983) and a Visual Analogue pain Scale (VAS) (Wewers and Lowe, 1990). All RLBP subjects reported the location of previous symptoms to be within the lumbar or lumbosacral region. All participants gave their informed written consent and the study was approved by the Institutional Human Ethics Committee.

2.2. Test procedure

Participants performed two activities in a sitting position; reaching across the body to a target and simulating pulling up a sock while the movements of their trunk and lower limb segments were monitored. For each functional activity, three continuous cycles of reaching and return were performed. Participants sat on a stool, initially with the trunk erect, arms hanging vertically, feet comfortably placed on the floor and looking directly forward. The stool provided bilateral support from the ischial tuberosities to mid-thigh and was adjusted to a height 110% of the distance from the fibular head to the floor (Rodosky et al., 1989) ensuring the feet were on the floor.

Table 1
Subject characteristics. Mean [SD] {range}.

	Control group	Recurrent low back pain (RLBP) group
Age (years)	28.6 [5.4]	34.0 [13.3]
Height (cm)	170 [9]	170 [11.5]
Body mass (kg)	67.0 [11]	71.5 [15]
BMI	23.0 [2.4]	24.5 [3.6]
Gender	13 F; 7 M	12 F; 8 M
Time since initial low back pain LBP onset (months)	–	33 {7–120}
Number of episodes of LBP	–	7.7 {3–25}
VAS pain score (/10)	–	1.8 {0–2.4}
Roland Morris (/24)	–	3.4 [2.9]

Cross-reaching required participants to touch a target positioned on the contralateral side, 40 cm lateral and 30 cm forward of the knee. Sock-dressing involved the use of both hands to lift a loose cloth ring from one ankle to halfway up the same shank. We wished to minimise the contribution of the lower limbs in order to achieve standardisation of performance and also better to examine the coordination of the trunk, therefore participants maintained their thighs on the stool throughout while otherwise performing the activity in a natural manner as possible, returning to the starting position in their own preferred manner between trials.

Participants familiarized themselves with the tasks under instruction from the researchers prior to recording, including achieving a notional target cadence of 0.25 Hz, which was used to reduce variability and avoid ballistic movements. Although tests were conducted to both sides, there were no significant or discernible differences between sides for any test in any participant, therefore only movement toward the left side will be reported. All participants performed both movements with no apparent difficulty and without reporting any discomfort.

2.3. Instrumentation

Movements were recorded using a multi-sensor, 6-degree-of-freedom (6_{dof}) electromagnetic tracking device (Motion Star Wireless® 2 system; Ascension Technology Corporation, Burlington, VT, USA) with an extended range transmitter unit, tracking sensors at 100 Hz within the transmitter-defined, global coordinate system (GCS). The system has a reported root mean square (RMS) accuracy of 0.3–0.8 mm for position and 0.15° for orientation and has been previously used and validated in the measurement of spinal kinematics (Crosbie et al., 2010; Thomas and Gibson, 2007).

Sensors were attached by adhesive and secured using Transpore® surgical tape over the spinous processes of the first and sixth thoracic and first lumbar vertebrae and the second sacral segment, defining the boundaries of the upper and lower thoracic and the lumbar regions (Crosbie et al., 2010). Sensors were also attached to the middle third of the lateral side of each thigh. A sensor attached to a stylus was used, with palpation, to digitize anatomical landmarks in the lower limbs and the trunk. The system was controlled through Motion Monitor® software, an integrated system which calibrated the hardware and configured the anthropometric characteristics of each participant. Checking of the security of the sensors was carried out by comparing the 6_{dof} values recorded for each sensor with respect to its neighbour before and after the tests. No significant differences were obtained for any of the trials, supporting the concept that the sensors had not moved on the skin during testing.

2.4. Data reduction

The digitised landmarks on the thorax and lower limbs transformed the sensor data from the GCS to anatomically based local coordinate systems. Lumbar spine movements were defined by the change in orientation of the sensor on L1 relative to the sensor on the sacrum, and the lower and upper thoracic movements as changes in the orientation of the sensor on the T6 relative to the sensor on the L1, and that on T1 to T6, respectively. Hip motion was the relative motion of the pelvis to the thigh, these segments being defined via virtual markers determined with respect to the relevant sensors at the time of digitisation. The method of computation was based on previously described techniques (Lee and Wong, 2002; Pearcy et al., 1987) and joint angles were derived from the direction cosine matrices of the sensors. Conventionally, flexion, leftward side bending and rightward axial rotation of the lumbar and thorax regions were positive in direction. Only the forward phase of each reach was analysed as this represented the active and purposeful component of the movement. Examination of the coordinates of the thigh sensors indicated that these remained static