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Asymmetric pelvic bracing and altered kinematics in patients with posterior pelvic pain who present with postural muscle delay

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ABSTRACT

Background: The purpose of the study was to examine the muscle activity and hip-spine kinematics in a group of individuals diagnosed with posterior pelvic girdle pain and confirmed postural muscle delay during a repeated fast hip flexion task.

Methods: Twenty-four (12 pain and 12 control) age and sex matched participants performed a repeated fast hip flexion task to auditory signal. Surface EMG activity in the external and internal oblique, the multifidus, the gluteus maximus and biceps femoris in the stance-limb was examined for onset timing and EMG integral. Sagittal plane hip (swing limb) and spine kinematics were examined for group and side differences over the repeated trials.

Findings: While the pain group lacked significant feedforward muscle activity they displayed higher muscle activity at movement onset in the biceps femoris bilaterally ($p < 0.05$) as well as the external oblique ($p < 0.05$) during motion of the symptomatic side. Furthermore, the pain group experienced asymmetrical spinal range of motion with increased motion on the contralateral side ($p < 0.001$) and reduced flexion velocity on the symptomatic side ($p < 0.001$).

Interpretation: The findings support previous hypotheses regarding the effect of increased biceps activity on pelvic control during lumbo-pelvic rotation. Further, there appears to be a symptom led strategy for bracing the innominate through opposing tension in the biceps and external oblique during movement of the painful side. Such asymmetrical pelvic girdle bracing may be a strategy to increase the stability of the pelvis in light of the failed load transfer mechanism. Putatively, this strategy may increase the mechanical stress on the sacroiliac joint exacerbating pain complaints.

1. Introduction

Back pain is a costly clinical problem with at least 80% of the population experiencing this disorder at some point in their life (Walker et al., 2004). The joints of the pelvic girdle have been identified as the source of low back and buttock pain for approximately 15–30% of the population (Mens et al., 2002). While a large proportion (20–70%) of pregnant women experience pelvic girdle pain (PGP), it is not solely a pregnancy related problem and only a small proportion (10%) of pregnancy related PGP will develop into chronic PGP that is maintained after the postpartum period (Rost et al., 2006). Pelvic girdle pain (PGP) is also associated with trauma, arthritis and spondyloarthropathies. Moreover, recent research has found nociceptors to be present throughout the joint capsule, ligaments and potentially into the subchondral bone, which suggests that trauma to any of the surrounding structures may be an aetiology of PGP (Szadek et al., 2008, 2010). PGP is most commonly felt between the posterior iliac crest and the gluteal fold, particularly in the area of the sacroiliac joints (Vleeming et al., 2008). A person experiencing PGP is also considered likely to have dysfunctional load transfer through the pelvis manifest in their diminished endurance for standing, walking, and sitting (Vleeming et al., 2008).

Faulty load transfer through the pelvic joints has been identified as a significant contributor to SIJ pain (Pool-Goudzwaard et al., 1998; Pel et al., 2008). Load transfer through the pelvic joints is a dynamic process involving joint reaction forces, joint position, proprioceptive muscle activation, muscle contractions and ligament tension (Vleeming et al., 2008). Controlling joint position through proprioceptive muscle activation is known as the self-bracing mechanism (Snijders et al., 1993). Self-bracing is dependent upon feedforward activation of local muscles of the lumbo-pelvic-hip complex (Hungerford et al., 2003). Patients with PGP appear to have functional insufficiencies in the self-bracing mechanism linked to altered muscle activation patterns and feedforward deficiencies during load transfer tasks (Hungerford et al., 2003; O'Sullivan et al., 2002). It is thought that such functional insufficiencies will lead to overloading of the pelvic joints which may render a person more susceptible to pain (Vleeming et al., 2008; Pool-Goudzwaard et al., 1998; Pel et al., 2008).

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Ineffective load transfer through the pelvic ring will putatively affect the loading and kinematics of the lumbar spine, particularly when pelvic stability is challenged through hip driven perturbations that are likely to generate and transfer additional and asymmetric forces through the sacro-innominate complex to the lumbo-sacral junction, such as the ASLR or modified Trendlenburg test. In order to explore for this phenomenon the present study is an investigation of muscle activity and hip-spine kinematic relationships in a group of patients clinically diagnosed with posterior PGP and confirmed feedforward muscle delay.

2. Methods

2.1. Participants

Twenty-four volunteer participants (14 females and 10 males) gave informed consent to take part in this study. Twelve of these were recruited from a larger sample of low back pain (LBP) participants who were taking part in a study investigating the use of clinical screening for symptoms of posterior pelvic pain, which are symptoms of SIJ origin, using current European guideline recommendations (Vleeming et al., 2008). All 12 of these participants fulfilled guideline criteria for LBP of SIJ origin, 10 presenting with predominantly right sided symptoms and two with bilateral symptoms. A further 12 participants were healthy age, sex and BMI matched controls (Table 1) recruited from the general population. All pain participants were evaluated by a qualified manual therapist (MPHTY) with considerable experience in diagnosing and treating LBP patients (>7 years). The guideline recommended confirmatory SIJ tests included: posterior pelvic pain provocation test (P4/thigh thrust), Gaenslen's test, Patrick's Faber, Compression test and the distraction test. The presence of symptoms was assessed with the use of a pain drawing diagram, visual analogue scale (VAS) as well as the Oswestry disability index. As per literature recommendations (Vleeming et al., 2008; Stuber, 2007; Laslett et al., 2005) patients were accepted as SIJ symptom positive if they had 3 or more positive pain provocation tests (plus positive ASLR), and located their pain between the posterior iliac crest and the gluteal fold. The main exclusionary criteria were pain located in the pubic symphysis or primarily within the lumbar spine.

2.2. Equipment

Ten Vicon© MX T20 cameras were used to collect three-dimensional kinematics of the trunk, pelvis and lower limbs at 100Hz, while ground contact forces and moments were measured with a force platform (AMTI LG6-3-1, AMTI, USA) collecting at 1000 Hz with an amplifier gain of 1000. Fifty two retroreflective markers were placed over the anatomical landmarks of interest. Standard local segment coordinate systems were used as per ISB recommendations. The thigh segment was defined by calibration markers placed on the greater trochanters, the medial and lateral femoral epicondyles. A cluster of 4 motion tracking markers was placed on the lateral aspect of the thigh. The hip joint centre was determined using a functional approach where each participant performed a series of flexion/extension, abduction/adduction and external/internal rotation activities prior to the stork trials (Begon et al., 2007; Schwartz and Rozumalski, 2005; European Commission, 1999). The pelvis segment was defined using markers placed bilaterally on the anterior superior iliac spines (ASIS) and the posterior superior iliac spines (PSIS) markers placed on the mid iliac crest were used in tracking. The origin of the pelvis segment coordinate system is defined as the mid-point between the ASIS markers. The trunk segment was defined using calibration markers placed on the sternum, C7, T9, T12, L3, L5 and bilaterally on the acromioclavicular (AC) joints. The origin of the trunk segment was defined by a virtual marker located in the L3 vertebral body.

Table 1
Descriptive statistics, means with standard deviation (SD), for groups including results of one-way ANOVA.

	Controls	**PGP**	**p-value**
Age (yrs)	29.7 (8.3)	31.0 (8.2)	0.282
Height (mm)	170.4 (9.3)	169.8 (6.3)	0.243
Mass (kg)	69.8 (11.8)	70.7 (10.9)	0.920
BMI (kgm^2)	23.5 (2.4)	23.9 (3.2)	0.849
Onset Pain (yrs)	N/A	5.3 (4.3)	N/A
Vas	N/A	26.1 (19.3)	N/A
Owestery	N/A	11.6 (6.5)	N/A
Hip int (°) (L-R)	38 (4) – 38 (5)	39(9) – 38 (3)	0.883
Hip ext (°) (L-R)	32 (8) – 35 (5)	21(6) – 24(8)	<0.001
Hip abd (°) (L-R)	41 (5) – 41 (5)	35(5) – 34(6)	0.002
IN$_{sag}$ L(°)	5.0 (2.9)	4.1 (3.3)	0.980
IN$_{sag}$ R(°)	2.5 (3.5)	−2.7 (2.6)	<0.001

IN sag = sagittal plane range of motion between the innominate bones during modified FABERs testing.

Electrical activity of the muscles was recorded from the right and left side external oblique, internal oblique, multifidus, gluteus maximus and biceps femoris using a telemetry EMG (Noraxon Telemyo 900, Noraxon USA inc.) collecting at 1000Hz. EMG signals were bandpass filtered between 16 and 499Hz and amplified (gain 1000). Surface areas were prepped for electrode placement by shaving, lightly abrading and cleaning with alcohol swipes then two disposable Ag/AgCl surface electrodes rectangular size 30 × 20 mm (Ambu® Blue Sensor N) were placed over the muscle belly so that the center of the electrodes were 20 mm apart. Electrode placements for the multifidus (MF), gluteus maximus (GM) and biceps femoris (BF) were as per the European Recommendations for Surface Electromyography (European Commission, 1999) while the external oblique (OE) electrodes were placed as per recommendations of (McGill et al., 1996) and internal oblique (TrA/OI) were positioned near horizontal, and inferior-medial to the ASIS within a triangle defined by inguinal ligament, linea alba and both ASIS (Marshall and Murphy, 2003).

2.3. Procedure

Prior to conducting the biomechanical testing each participant completed a participant profile and underwent clinical measurements of hip and innominate motion. Hip range of motion was measured in the abduction and internal/external rotation directions by the examining clinician using a goniometer. Innominate range of motion was measured using a modified Fabers position by an experienced clinical researcher using the methodology developed, described and published by (Bussey et al., 2009). Sagittal plane rotations of the innominate were calculated as a composite angle between the two innominates rotating about the mediolateral axis of the pelvis (Bussey et al., 2009). The maximum angle measured during the test was taken as the sagittal innominate range of motion (IN$_{sag}$, Table 1).

Following these procedures participants then moved to the Biomechanics Laboratory where they were prepared for motion analysis. The participants were asked to stand quietly on the force platform with feet positioned hip width apart. Upon hearing a distinctive auditory signal, they were immediately required to flex one of their hips up to 90° and back to normal stance as quickly as possible. The standing hip flexion test to auditory signal was repeated 20 times for each leg with randomized and inconsistent time interval between auditory signals in order to minimize participant anticipation of the signal. Both the left and right limbs were tested in a random order such that the symptomatic side was examined in both stance and swing conditions. For the purposes of this study, only the muscles of the stance-limb side are considered for analysis and thus, no analysis was conducted on the swing-limb muscle groups, so for example when hip flexion is occurring on the right the muscles on the left side of the body are being analysed.