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Anticipatory postural control differs between low back pain and pelvic girdle pain patients in the absence of visual feedback

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ABSTRACT

Purpose: The aim of this study was to examine the effect of vision on anticipatory postural control (APA) responses in two groups of clinically diagnosed chronic low back pain patients, those with Posterior Pelvic Girdle pain and those with Non-Specific Low Back Pain compared to a matched group of healthy controls during the modified Trendelenburg task.
Methods: Seventy-eight volunteer participants (60 females and 18 males) gave informed consent to take part in this study. 39 with confirmed LBP or PGP lasting longer than 12 weeks and 39 healthy matched controls performed 40 single leg lift tasks (hip flexion to 90° as quickly as possible) with their non-dominant lower limb. A force plate was used to determine the medial-lateral displacement of the center of pressure, and the initiation of weight shift; kinematics was used to determine initiation of leg lift; and electromyography was used to determine onset times from the external oblique (EO), internal oblique (IO) and lumbar multifidus (MF), gluteus maximus (GM) and biceps femoris (BF).
Results: The PGP group showed significantly longer muscle onset latencies in the BF, EO MF with visual occlusion ($F_{2,746} = 4.51$, $p < .0001$).
Conclusion: The muscle onset delays identified between the two LBP sub-groups suggests that pain may not be the primary factor in alteration of APA response. The PGP group show a greater reliance on vision which may signal impairment in multiple feedback channels.

1. Introduction

Non-specific chronic Low Back Pain (NSLBP) is the most frequent form of low back pain accounting for up to 85% of the patients (Van Tulder, Assendelft, Koes, & Bouter, 1997). It has been estimated that 15–30% of NSLBP patients have pain arising from the sacroiliac joints (Maigne, Aivaliklis, & Pfefer, 1996; Schwarzer, Aprill, & Bogduk, 1995). Posterior pelvic girdle pain (PGP) has been described as a unique form of LBP with pain located between the posterior iliac crest and the gluteal fold predominantly in the area of the sacroiliac joints (Vleeming, Albert, Ostgaard, Sturesson, & Stuge, 2008). There is a substantial body of evidence suggesting that NSLBP has a significant impact on postural control e.g., (D'hooge et al., 2013; Ferreira, Ferreira, & Hodges, 2004; Tsao & Hodges, 2007; Urquhart, Hodges, & Story, 2005). However, much less attention has been focused on the effect of PGP.

Anticipatory activation of deep muscles (e.g., transverse abdominis, erector spinae) is seen as key to maintaining lumbo-pelvic

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stability during predictable postural perturbations, such as those encountered during limb movement (Hodges & Richardson, 1996; Morris, Lay, & Allison, 2013; Panjabi, 1992). This form of postural control is known as anticipatory postural adjustments (APA). APAs reflect the central nervous system (CNS) organization to maintain the body's centre of mass over its base of support by counteracting the predictable intrinsic reactive forces induced by a focal movement through pre-activation of particular muscle groups (Belen'kii et al., 1967). Stronger APA responses in lumbar spine muscles, such as the erector spinae and lumbar multifidus have been associated with increased body sway and greater amplitude in centre of pressure (COP) (Xie & Wang, 2019). While week or absent APAs, as often observed in Parkinson's patients, tend to be associated with reduced CoP amplitudes (Lu, Amundsen Huffmaster, Tuite, Vachon, & MacKinnon, 2017). Multiple studies have shown that LBP or PGP patients have altered anticipatory activation in key stabilising muscles. For instance, both PGP and LBP patients have demonstrated anticipatory delays in the transverse abdominis/internal oblique and multifidus during postural tasks (shoulder flexion for LBP and hip flexion for PGP) (Bussey & Milosavljevic, 2015; Hodges & Richardson, 1998; Hungerford, Gilleard, & Hodges, 2003; Jacobs, Henry, Jones, Hitt, & Bunn, 2011; Suehiro et al., 2015). Delays in anticipatory muscle activation may be a CNS adaptation response to pain (Hodges & Tucker, 2011) potentially resulting in failure of lumbo-pelvic stabilization leading to recurrent pain patterns (Hodges, Cresswell, Daggfeldt, & Thorstensson, 2001; Hungerford et al., 2003; Richardson et al., 2002).

Anticipatory postural control is dependent upon the ability of the motor system to accurately estimate the sensorimotor consequences of future efferent signalling (Desmurget, 2003). While studies show some similarities between anticipatory deficits in NSLBP and PGP groups (as shown above), there are also important differences. PGP groups also display anticipatory changes in activation of the hip musculature such as the bicep femoris and gluteus maximus (Bussey & Milosavljevic, 2015; Hungerford et al., 2003). Hip proprioceptive feedback is important for maintaining mediolateral stability during gait (Roden-Reynolds, Walker, Wasserman, & Dean, 2015) and indeed, one of the primary symptoms of PGP is difficulty walking (Stuge, Garratt, Krogstad Jenssen, & Grotle, 2011; Vleeming et al., 2008). Certainly, PGP groups display greater alterations in spine-pelvis coordination, particularly at high speeds, compared to NSLBP (Huang et al., 2011; Lamoth, Meijer, Daffertshofer, Wuisman, & Beek, 2006; Wu et al., 2008). Furthermore, previous research has shown that PGP groups use excessive compensatory activation of the biceps femoris when performing a Trendelenburg task, which highlights potential errors in predicting the sensorimotor state during a task that challenges mediolateral stability (Bussey & Milosavljevic, 2015). Mechanically-induced reductions in the reliability of somatosensory information increases the reliance on other systems, such as vision, for accurate information upon which to base predictions of future sensorimotor state (Goossens, Janssens, Caeyenberghs, Albouy, & Brumagne, 2019; Simmons, 2005).

While there is a scarcity of motor control research on PGP, there is a growing body of evidence that NSLBP patients may have increased reliance on visual information for postural control (Brumagne, Cordo, & Verschueren, 2004; Brumagne, Janssens, Janssens, & Goddyn, 2008; Newcomer, Laskowski, Yu, Johnson, & An, 2000; Sung, Abraham, Plastaras, & Silfies, 2015). Vision is one of the most reliable human sensory systems and provides crucial feedforward information for movement planning (Rossetti, Desmurget, & Prablanc, 1995). Constraints on visual information will increase the dependence of movement planning on the remaining sensory sources such as the proprioceptive and vestibular systems (Day & Guerraz, 2007). Hence, overreliance on visual feedback in NSLBP may be the result of reduced proprioceptive input from the musculoskeletal structures around the spine (Brumagne, Cordo, Lysens, Verschueren, & Swinnen, 2000; Brumagne, Janssens, Knapen, Claeys, & Suuden-Johanson, 2008).

Populations with pathophysiological impairments (e.g., Parkinson's, or LBP) present with aberrant APAs (attenuation or delays) that do not appear to adapt when exposed to situations of postural uncertainty (Jacobs, Henry, & Horak, 2018), whereas young healthy populations display APAs that are highly adaptable (Yiou, Caderby, & Hussein, 2012). When faced with a novel postural challenge, such as altered base of support (Caderby et al., 2017; Simmons, 2005), muscle fatigue (Morris & Allison, 2006; E Yiou, Ditcharles, & Le Bozec, 2011), gait obstacles (Yiou, Artico, Teyssedre, Labaune, & Fourcade, 2016) or fear of falling (Adkin, Frank, Carpenter, & Peysar, 2002) the healthy person's CNS responds by adapting the amplitude or duration of the APA in order to optimise postural response for that situation. For instance, when healthy populations are faced with a single leg stance task, a situation of instability whereby the muscular system is restricted in its capacity for force production, participants lengthened the APA duration as a mechanism to maintain the focal performance without excessive perturbation (Yiou, Yiou, Mezaour, & Le Bozec, 2009).

The aim of this study is to examine the effect of visual feedback on the APA muscle responses in two groups of clinically diagnosed chronic low back pain patients (PGP and LBP) and a group of healthy controls during a typical clinical functional test, the modified Trendelenburg. The two primary hypotheses for the study are (1) Pain groups will have a significantly altered APA response marked by increased muscle onset delays and lower CoP amplitude and APA duration compared to healthy controls, and (2) visual occlusion will amplify differences between the pain and healthy groups. We would expect the healthy controls to display adaptation to the removal of visual information, likely with increased APA duration, shorter muscle onset latencies but no significant change in CoP amplitudes. Compared to healthy controls we expect the pain groups to display maladapted APA responses to visual occlusion, based on previous research we would expect the LBP group to have few if no changes in APA parameters in this condition. Due to a lack of research in the area it is difficult to make informed predictions regarding the PGP, thus, we further aim to explore and compare the effect of visual occlusion on APA response between sub-groups.

2. Methods

2.1. Participants

Sample size was estimated via mixed model simulation with a previous data set to determine the number of observations required to detect minimally important difference in the interaction term (EYES x Group). The present study was approved by the University of