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Reorganised anticipatory postural adjustments due to experimental lower extremity muscle pain

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A B S T R A C T

Automated movements adjusting postural control may be hampered during musculoskeletal pain leaving a risk of incomplete control of balance. This study investigated the effect of experimental muscle pain on anticipatory postural adjustments by reaction task movements. While standing, nine healthy males performed two reaction time tasks (shoulder flexion of dominant side and bilateral heel lift) before, during and after experimental muscle pain. On two different days experimental pain was induced in the m. vastus medialis (VM) or the m. tibialis anterior (TA) of the dominant side by injections of hypertonic saline (1 ml, 5.8%). Isotonic saline (1 ml, 0.9%) was used as control injection. Electromyography (EMG) was recorded from 13 muscles. EMG onset, EMG amplitude, and kinematic parameters (shoulder and ankle joint) were extracted. During shoulder flexion and VM pain the onset of the ipsilateral biceps femoris was significantly faster than baseline and post injection sessions. During heels lift in the VM and TA pain conditions the onset of the contralateral TA was significantly faster than baseline and post injection sessions in bilateral side. VM pain significantly reduced m. quadriceps femoris activity and TA pain significantly reduced ipsilateral VM activity and TA activity during bilateral heel lift. The EMG reaction time was delayed in bilateral soleus muscles during heels lift with VM and TA pain. The faster onset of postural muscle activity during anticipatory postural adjustments may suggest a compensatory function to maintain postural control whereas the reduced postural muscle activity

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during APAs may indicate a pain adaptation strategy to avoid secondary damage.

1. Introduction

In elderly people knee-related pain is one of the most frequent symptoms of the musculoskeletal system (Cecchi et al., 2008; Guccione et al., 1993; Jørgensen et al., 2011; Lawrence et al., 2008; Tennant et al., 1995; Yoshimura et al., 2009). Often knee pain not only affects spinal reflex excitability, perception sensitivity, and pain threshold (Arendt-Nielsen et al., 2010; Leroux, Bélanger, & Boucher, 1995; Voight & Wieder, 1991), but the pain also reduces the joint kinematic amplitude of the dynamic performance during stepping, lunge movement, walk, and stair climbing (Astephen, Deluzio, Caldwell, Dunbar, & Hubley-Kozey, 2008; Henriksen, Alkjaer, Simonsen, & Bliddal, 2009; Mouchnino et al., 2005; Verweij, van Schoor, Deeg, Dekker, & Visser, 2009). Furthermore, knee pain may increase the risk of fall and unbalanced posture in elderly people (Foley, Lord, Srikanth, Cooley, & Jones, 2006).

Experimental pain induced in the patellar fat pad (Bennell, Hodges, Mellor, Bexander, & Souvlis, 2004; Hirata, Arendt-Nielsen, Shiozawa, & Graven-Nielsen, 2012) or knee-related muscles (Graven-Nielsen, Lund, Arendt-Nielsen, Danneskiold-Samsøe, & Bliddal, 2002; Henriksen et al., 2011; Hirata, Ervilha, Arendt-Nielsen, & Graven-Nielsen, 2011) by injections of hypertonic saline have been used to study the link between knee pain and motor control function in humans. Experimental knee-related pain affects the motor unit firing rate during voluntary contraction of m. quadriceps femoris (Tucker & Hodges, 2009), reduce the maximum isometric and isokinetic force (Graven-Nielsen et al., 2002; Henriksen, Rosager, Aaboe, Graven-Nielsen, & Bliddal, 2011), attenuate the functional performance during gait (Henriksen et al., 2007), forward lunge (Henriksen et al., 2009), stair climbing (Hodges, Mellor, Crossley, & Bennell, 2009), and reduce postural stability during quiet standing (Hirata et al., 2011, 2012). In knee-pain patients other pathological factors (e.g. degenerated joint) may affect the motor control (Chang et al., 2004; Foroughi et al., 2010; Henriksen, Graven-Nielsen, Aaboe, & Andriacchi, 2010) but the experimental pain studies indicate that knee-related pain per se can impede the motor control significantly.

Anticipatory postural adjustments (APAs) are generated in a feed-forward capacity by the central nervous system to stabilise the body against the anticipated perturbing forces (Belen'kii, Gurfinkel, & Pal'tsev, 1967; Bouisset & Zattara, 1981, 1987). In some reaction time tasks APAs are observed as predictive and reactive functions. For example, during shoulder flexion reaction task, the bilateral m. biceps femoris are typically used as part of the APA along with other muscles in the kinematic chain (Belen'kii et al., 1967; Bouisset & Zattara, 1981). In the heel lifting reaction task, the muscle onset of the bilateral m. vastus medialis and bilateral m. vastus lateralis during APA is initiated centrally by the anticipated movement (Cowan, Hodges, & Bennell, 2001).

In previous studies, shoulder flexion task and bilateral ankle movement task were used to investigate the relationship between musculoskeletal pain and APA (Cowan, Hodges, Bennell, & Crossley, 2002; Cowan et al., 2001; Falla, Jull, & Hodges, 2004; Hodges, 2001; Hodges, Moseley, Gabrielsson, & Gandevia, 2003; Silfies, Mehta, Smith, & Karduna, 2009). The shoulder flexion task and bilateral heel lift task induced different APAs strategies. The APAs during shoulder flexion mainly counterbalance the acceleration of the centre of mass of the body caused by the unilateral arm movement, in order to maintain the equilibrium, whereas in heels lift the APAs that move the centre of mass forward are aimed to create the conditions for movement execution. Therefore during bilateral heel lift task, pain around the ankle joint might not only alter the APA strategy but also affect the target movement performance. Furthermore, APAs in painful conditions are interesting because it is not under voluntary control; i.e. the pain effect on APA is a non-voluntary neurophysiologic effect of nociception. Previous studies showed that neck pain and low back pain induced delayed onset activity of postural muscles during shoulder flexion reaction tasks (Hodges, 2001, 2003; Falla et al., 2004) and reduced trunk's muscle activity of during APAs (Hodges et al., 2003). Moreover, the bilateral heel lift task in patients