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Original article

Laterality recognition of images, motor performance, and aspects related to pain in participants with and without wrist/hand disorders: An observational cross-sectional study

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ABSTRACT

Objective: Musculoskeletal disorders are associated with altered sensory, proprioceptive and cognitive processes. Sensory processes affect the internal cortical representation of the body in space, the body schema, which in turn influences motor control. The purpose of this study was to determine if participants with wrist/hand disorders had impaired performance on a task associated with the body schema, the Left/Right Judgement Task (LRJT) and secondly how LRJT performance, motor performance, disability, pain and related aspects are associated.
Methods: Fifteen healthy control participants and 15 participants with hand/wrist pain were asked to determine the laterality of images of hands. Measures of motor performance (Purdue Pegboard test), self-reported disability (Australian Canadian Hand Index), and pain related aspects (pain intensity, symptom duration, pain interference and affective distress) were recorded.
Results: Participants with wrist/hand pain scored lower on all segments of the Purdue Pegboard test. There were differences in LRJT performance between groups for both Accuracy ($p = 0.03$) and Reaction Time (RT) ($p < 0.01$). There was no correlation between RT and Accuracy with pain intensity, pain duration, and disability. Both motor performance ($r = 0.58$–0.64) and LRJT performance Accuracy ($r = 0.59$) and RT ($r = -0.56$) were correlated with affective distress. A significant correlation was observed between RT and motor performance in healthy control participants ($r = -0.56$, $p = 0.03$) but not in participants with wrist/hand pain ($r = -0.26$, $p = 0.44$).
Conclusions: LRJT and motor performance was correlated with affective distress in participants with wrist/hand pain suggestive of complex interactions between cognitive-affective processes and sensorimotor integration.

1. Introduction

Altered sensory and proprioceptive processes are well characterized in participants with musculoskeletal disorders (MSD). These include findings of increased two-point discrimination threshold, changes in perception threshold to noxious and innocuous stimuli, sensory stimuli being processed more slowly, incorrect localization, and decreased accuracy in recognizing tactile stimulation (Sharma and Pai, 1997; Tinazzi et al., 2000; Wilder-Smith et al., 2002; Brumagne et al., 2004; Giesecke et al., 2004; Jensen et al., 2008; Fernandez-Carnero et al., 2009; Fernandez-de-las-Penas et al., 2009; Wand et al., 2010; Luomajoki and Moseley, 2011; Wilgen et al., 2011; Moseley et al., 2012; Stanton et al., 2013). Sensory changes in participants with MSD have been demonstrated bilaterally and in sites remote to the initial injury (Smeulders et al., 2002; Jensen et al., 2008; Fernandez-Carnero et al., 2009) including increased pain thresholds in participants with osteoarthritis of the thumb (Chiarotto et al., 2013a,b). Participants with MSD may also experience proprioceptive deficits (Garn and Newton, 1988; Warner et al., 1996; Sharma and Pai, 1997; Newcomer et al., 2000; Treleaven et al., 2006; Coombes et al., 2009; Huysmans et al., 2010; Hodges, 2011) including decreased joint position sense (Brumagne et al., 1999; O'Sullivan et al., 2003; Huysmans et al., 2010), decreased ability to detect joint motion (Gill and Callaghan, 1998; Field, 2009), and difficulty to adopt postures seen on a photograph (Luomajoki and Moseley, 2011; Moseley et al., 2012).

Sensory and proprioceptive information is utilized to create an internal representation of the body in peri-personal space, the body schema, that is accessed for effective engagement with the

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Abbreviations

AUSCAN™	Australian Canadian Osteoarthritis Hand Index
LRJT	Left/Right Judgement Task
MSD	Musculoskeletal Disorders
RT	Reaction Time
WHYMPI	West Haven Yale Multidimensional Pain Inventory

environment. The Left/Right Judgement Task (LRJT) requires participants to determine if images of body parts are of the left or right side (Parsons, 2001; Moseley, 2004). The LRJT is believed to involve the body schema as performance on this task is affected by the complexity of transformations to be performed to adopt the position of the participant's anatomical part congruent to the image presented (Schwoebel et al., 2001; Ionta et al., 2007; Coslett et al., 2010a,b, Reinersmann et al., 2012). Studies in participants with MSD have found variable changes in LRJT performance including Reaction Time (RT), the time taken to identify the laterality of the image of a body part, and Accuracy, the correctness of the given response (Schwoebel et al., 2001; Coslett et al. 2010a,b, Schmid and Coppieters, 2012; Stanton et al., 2012, 2013; Pedler et al., 2013; Elsig et al., 2014) suggesting that the body schema is affected in at least some persons with MSD.

Altered motor processes such as bilateral changes in strength and motor control are also characteristic of participants with upper limb MSD (Bisset et al., 2006), including hand injuries (Forget et al., 2008) suggesting that participants with upper limb MSD may experience bilateral changes in motor processes. In addition, participants with MSD also experience changes in cognitive-affective-motivational areas of the brain (see (Apkarian et al., 2009, 2011; Wiech and Tracey, 2013)). These cognitive-affective-motivational areas are associated with psychological and behavioral changes (see (Campbell and Edwards, 2009)). Psychological factors would appear to impact sensorimotor processes. For example, fear of movement measured with the Tampa Scale of Kinesiophobia is associated with an increase of electromyographic activity during performance of tasks in participants with MSD (Masse-Alarie et al., 2016). Changes in corticospinal excitability including decreased modulation of intracortical motor cortex inhibitory processes has been associated with acute mental stress associated with a complex mental task (Marker et al., 2014). Psychological factors associated with positive Waddell signs have also been found to impact changes in somatotopic organisation in the primary somatosensory cortex (Lloyd et al., 2008). Depression and stress has also been shown to mediate the relationship between pain and disability in participants after wrist/hand fractures (Ross et al., 2015). Study results therefore suggest that MSD are associated with cognitive-affective changes that interact with sensorimotor processes.

As sensorimotor processes as well as cognitive affective processes appear to be affected in participants with MSD, it is conceivable that the relationship between LRJT, motor performance and cognitive affective aspects related to MSD of the hand would be different between participants with and without wrist/hand pain. We therefore hypothesized that motor performance of the hand would be affected in participants with heterogeneous MSD of the hand and wrist. Additionally, we hypothesized that motor performance and aspects related to pain such as pain intensity, pain interference and affective distress would be associated with poorer LRJT performance. This information is important for deciphering the relationship between neurophysiological changes in sensorimotor processes and MSD as these changes are considered as a potential avenue of treatment in this population (Snodgrass et al., 2014; Pelletier et al., 2015).

2. Methods

2.1. Participants

Participants experiencing unilateral wrist/hand pain (PAIN) for greater than three months and reported that their injury interfered with the performance of daily activities were recruited in the greater Montreal area, Canada from private rehabilitation clinics, social media and web-based advertising between September 2013 and January 2015. Healthy Control (CONTROL) participants were a sample of convenience and were free of previous injury to the upper extremity. Participants were excluded if they were diagnosed with dyslexia or experienced neurological or visual impairment. Participants were assessed for handedness with the Edinburgh Handedness Inventory (Oldfield, 1971). Fifteen participants with wrist/hand pain (7 female, 14 right hand dominant) and 15 CONTROL (10 female, 14 right hand dominant) participants participated in this observational cross-sectional study. Sample size was based upon experiments with significant findings utilizing LRJT performance as their outcome measure (Schwoebel et al., 2002; Nico et al., 2004; Moseley et al., 2005; Hudson et al., 2006; Ionta et al., 2007; Reinersmann et al., 2010). Experiments were performed at the Centre intégré universitaire de santé et services sociaux du Centre-Sud-de-l'Île-de-Montréal, Montréal Gingras-Lindsay Rehabilitation Institute. The study received ethical approval from the institutional review board, participants provided written informed consent, and the study was performed in accordance with the Declaration of Helsinki.

2.2. Measures

2.2.1. Laterality recognition test

Accuracy and RT for the recognition of images of hands were assessed using the Recognise™ (Neuro-orthopaedic Institute, Adelaide, Australia) application installed on an 8-inch computer tablet (Linder et al., 2016; Breckenridge et al., 2017). Participants were presented with 50 images of hands in different conformations on a plain background (vanilla images) with a maximum duration time per image of 5 s. Participants were instructed to provide a verbal response "as accurately and quickly as possible" as LRJT performance in both Accuracy and RT is better when participants provide verbal rather than manual responses, accuracy for the laterality of images is negatively affected on the side of the hand utilized to manually indicate laterality (Cocksworth and Punt, 2013), and it is also possible that changes in motor hand function to manually indicate laterality due to MSD of the hand would impact results (Fiorio et al., 2005). Participants were instructed not to move their hands during the task. The same examiner depressed the left and right keys on the tablet in both groups of participants. Participants practiced on 10 images prior to data collection. Total Accuracy was expressed as a percentage of correct responses while RT was the average of the trials for each hand expressed in seconds.

2.2.2. Pain

Pain severity and pain-related aspects such as pain interference and affective distress were assessed utilizing the West Haven Yale Multidimensional Pain Inventory (WHYMPI), with maximum values per subscale of 6 (Kerns et al., 1985), and part 1 of the Australian Canadian Osteoarthritis Hand Index (AUSCAN™, www.womac.com) (Bellamy et al. 2002a,b). Pain interference in the WHYMPI consists of nine items that pertain to how pain interferes (ability and satisfaction) in the patient's life including activities of daily living, work, social and familial activities. Affective distress involves three items pertaining to mood, irritability and anxiety.

2.2.3. Hand motor performance

Hand motor performance was assessed with the Purdue Pegboard test (Tiffin and Asher, 1948). The Purdue Pegboard test (Lafayette Instrument, model #32020, Lafayette, IN) is a time constrained motor