AN EXPLORATORY STUDY OF SENSORIMOTOR BRAIN AREAS INVOLVED IN PROCESSING PROPRIOCEPTIVE INPUTS FROM THE ANKLE AND BACK MUSCLES IN PATIENTS WITH NON-SPECIFIC LOW BACK PAIN

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Introduction

Non-specific low back pain (NSLBP) is a major public health problem worldwide. The underlying mechanisms of NSLBP are still not fully understood. Patients with NSLBP have a decreased capacity to adapt proprioceptive weighting during postural control compared to healthy controls. They rely more on ankle muscle proprioception and less on back muscle proprioception, even in more complex postural situations such as standing on an unstable support surface. This decreased proprioceptive weighting capacity is linked to structural brain changes. However, it is unknown whether there is also an association with functional brain changes, i.e. an impaired processing of proprioception from the ankles and lower back.

Purpose/Aim

To investigate which brain regions are involved in the processing of proprioceptive inputs from the ankle and back muscles in patients with NSLBP.

Materials and Methods

Three patients with NSLBP aged 24.3 ± 3.5 participated. They reported an average pain intensity of 4.5 ± 1.5 out of 10 on the Numerical Rating Scale. First, the proprioceptive weighting capacity during postural control was evaluated. Subjects stood on a stable and unstable support surface with vision occluded. Muscle vibraton (60 Hz) was applied bilaterally at the ankle and back muscles. This elicited a muscle-lengthening illusion and compensatory postural sway. Mean center-of-pressure displacements during muscle vibration were used to calculate the proprioceptive weighting ratio (RPW) with following equation: RPW = (absAnkle/(absAnkle + absBack). AbsAnkle and absBack represent absolute CoP displacement during ankle and back muscle vibration respectively. A ratio of 1 indicates 100% reliance on ankle muscle proprioception, whereas a ratio of 0 indicates 100% reliance on back muscle proprioception. Second, the central processing of proprioceptive inputs from the ankle and back muscles was studied by applying muscle vibration during task-related functional magnetic resonance imaging (fMRI). Vibration was applied at low (20 Hz) and high frequency (60 Hz), to induce respectively weak and strong discharges of muscle spindle Ia afferents. The contrast between the 60 Hz and 20 Hz conditions was computed with Statistical Parametric Mapping (SPM12) to gain insight into the cortical network involved in processing purely muscle proprioceptive inputs ($p< 0.05$, FWE corrected).

Results

RPW values during standing on the stable and unstable support surface were 73.3 ± 7.5 and 59.1 ± 3.2 respectively. One sample t-tests of the contrast 60 Hz > 20 Hz vibration revealed activation in several (sub)cortical regions. *Ankle muscle vibration* elicited bilateral activation in cerebellar lobules VI, primary somatosensory cortices, superior parietal lobules, inferior and superior frontal gyri and middle temporal gyri. Right-sided activation was found in cerebellar lobule VIII, primary motor cortex, SMA, anterior cingulate cortex, amygdala, caudate nucleus and putamen. Left-sided activation was seen in middle frontal gyrus, inferior temporal gyrus and insula. *Back muscle vibration* induced bilateral activation in inferior, middle and superior frontal gyri and middle temporal gyri. Right-sided activation was found in cerebellar lobule VI, inferior temporal gyrus, insula, caudate nucleus and putamen. Left-sided activation was seen in cerebellar crus II, primary somatosensory cortex, primary motor cortex and cingulate motor area.

Conclusion(s)

The results in three patients with NSLBP and a reduced proprioceptive weighting capacity during postural control showed that an extended (sub)cortical network was involved in processing proprioceptive inputs from two key postural muscles. This network consisted of sensorimotor areas, e.g. primary sensorimotor cortices, SMA, basal ganglia and cerebellar lobules VI and VIII as well as higher-association regions, e.g. superior parietal lobule and inferior frontal gyri. Ankle muscle proprioceptive processing elicited more brain activation than back muscle spindle stimulation. These results warrant further study in a larger sample of patients with NSLBP and healthy controls to provide more insight into the neural basis of (impaired) proprioceptive processing and postural control.

Keywords

Muscle Vibration, Proprioception, Functional Magnetic Resonance Imaging, Low Back Pain