Activation of the sensorimotor cortex by vibrotactile stimulation of the foot: An fMRI study.

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PURPOSE: The aim of the study was the development of a paradigm for functional magnetic resonance imaging (fMRI) for the investigation of brain activity within the sensorimotor cortical region of the foot sole. Therefore, a proper vibrotactile stimulus was developed and the elicited brain activation pattern was analyzed with regard to the applicability for functional diagnosis for the cortical area for the foot and the long afferent tracts for the foot.

METHODES: 10 healthy male subjects (25–45yrs) were stimulated with a vibrotactile stimulus above the basic joint of digit I of the foot. The stimulus was delivered through a fully automated moving magnet actuator with frequency (0-100Hz) and amplitude (0-4mm) control. To avoid adaptation phenomena a stimulus wave form was formed as the product of a fixed vibration carrier signal and a modulation term which varied sinusoidally. The carrier frequency was held constant at 100 Hz at a fixed modulation frequency of 25Hz and a fixed stimulus intensity of 0.05N throughout the fMRI run. Experiments were performed on a 1.5Tesla MR-scanner. For fMRI, we employed T2*-weighted single shot echoplanar sequences (TR/TE/α=0,96ms/66ms/90°,matrix=64x64, acquisition time: 2sec, voxel dimension=4x4x4mm). Twenty-four slices parallel to the bicommissural plane were simultaneously acquired. Five stacks of images during vibration off (condition R) were alternated with five stacks of images during vibration on (condition A) up to a total volume of 85 stacks of images. The scan repetition time for the stimulus on/off conditions was 3s. Post-processing was performed offline with SPM99. A statistical parametric activation map was calculated for each of the 10 subjects and for the group of subjects with an uncorrected $p<0.001$ on a cluster level of $k>8$.

RESULTS: FMRI group data of the 10 subjects shows brain activity: 1. bilaterally within the secondary somatosensory cortex located in the inferior parietal lobule, 2. contralaterally to the stimulated side within the primary sensorimotor cortex located in the pre- and postcentral gyrus, 3. bilaterally within the supplementary motor cortex medially lying in the superior frontal gyrus and 4. on the right hemisphere within the anterior cingulate gyrus.

CONCLUSION: In the present study, an fMRI paradigm for vibrotactile stimulation of the foot sole could be developed. The stimulus can be well defined, frequency and amplitude can be controlled. The stimulus with a modulation frequency of 25Hz induces brain activation within the sensorimotor cortex for the right foot within a group of ten healthy volunteers. However, for the application in clinical functional diagnosis, the parameters of the stimulus still need to be optimized to yield a robust activation pattern. The results hold promise for the applicability of the presented vibrotactile stimulus in functional diagnosis of the cortical area for foot and the long afferent tracts. Functional diagnosis of the sensorimotor system in fMRI using the presented vibrotactile stimulus can further help for the understanding of pathological conditions of the sensorimotor system due to microgravity or simulated weightlessness as well as for the development of therapeutic strategies especially for bedrest syndrome or space motion sickness.

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