Feasibility of a novel MEG-compatible proprioceptive stimulator of the knee joint

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Tiivistelmä:
Cortical processing of proprioceptive afference to passive movements has been investigated using magnetoencephalography (MEG), but the focus has been on hand and ankle joint, whereas the knee joint has received considerably less attention. Here we introduce a novel MEG-compatible proprioceptive stimulator of the knee joint to elicit patellar tendon reflex and to quantify the corresponding cortical responses.

Twenty-five healthy volunteers (24 right-foot dominant, 30.3 ± 4.3 yr, 11 females) were recruited in the study, including two MEG measurements. One hundred proprioceptive stimuli were delivered every ~5.5 ± 0.5 s to the right patellar tendon using a hammer-based stimulator separately at low and high intensity, modulated by varying the hammer drop height. The kinematics of the stimuli were measured with an accelerometer, while the brain responses were recorded with whole-head MEG and muscle activity of vastus lateralis (VL) and vastus medialis (VM) with surface electromyography (EMG). Peak responses were quantified for the acceleration magnitude, EMG amplitude, and phase-locked (evoked) and non-phase-locked (induced) fields.

Nineteen participants showed clear EMG and MEG responses confirming the feasibility of the stimulation approach. The peak acceleration magnitudes of the stimuli remained consistent throughout the measurements, with coefficient of variation (CoV) of 13.2% (high) and 14.2% (low). CoV for the peak evoked field amplitude (high 28.1% and low 29.7%) and, the relative strength of beta rhythm suppression (high 25.2% and low 36.7%) and rebound (high 41.1% and low 43.9%) was less compared to muscular EMG response (CoV ≥ 98.5% for VL and VM). The high intensity stimulation produced significantly stronger peak evoked field ($p = 0.002$), suppression ($p = 0.004$) and rebound ($p = 0.036$) amplitudes than low intensity one.

The results indicate that our novel knee joint proprioceptive stimulator is feasible to investigate the cortical processing of proprioceptive afference elicited in the patellar tendon, enabling its reproducible stimulation in a controlled and non-invasive manner. Thus, it is a valid tool for longitudinal studies assessing proprioceptive deficits in clinical populations, such as individuals with knee osteoarthritis (OA) or total knee replacement patients (TKR).