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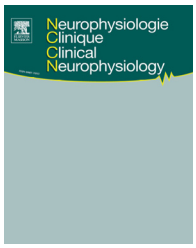

ORIGINAL ARTICLE/ARTICLE ORIGINAL

Effect of movement rate on corticokinematic coherence

Effet de la fréquence de mouvement sur la cohérence corticocinématique

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KEYWORDS
Magnetoencephalography;
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Summary
Aims of the study. — This study investigates the effect of movement rate on the coupling between cortical magnetoencephalographic (MEG) signals and the kinematics of repetitive active finger movements, i.e., the corticokinematic coherence (CKC).
Material and methods. — CKC was evaluated in ten right-handed healthy adults performing repetitive flexion—extension of the right-hand fingers in three different movement rate conditions: slow (~1 Hz, duration: 11 min), medium (~2 Hz, duration: 5 min) and fast (~3 Hz, duration: 3 min). Neuromagnetic signals were recorded with a whole-scalp-covering MEG (Elekta Oy) and index acceleration was monitored with a 3-axis accelerometer. Coherent sources were estimated on the time-course of the cross-correlogram using equivalent current dipole (ECD) modeling.
Results. — Significant coherence was found at movement frequency or its first harmonics in all subjects and movement conditions. ECDs clustered at the primary sensorimotor cortex contralateral to hand movements. Movement rate had no effect on the coherence levels and the location of coherent sources.

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Conclusions. — This study demonstrates that the movement rate does not affect coherence levels and CKC source location during active finger movements. This finding has direct implications for CKC functional mapping applications and studies investigating the pathophysiology of central nervous disorders affecting proprioceptive pathways.

MOTS CLÉS
Magnétoencéphalographie ;
Cohérence corticocinématique ;
Cartographie fonctionnelle ;
Sensorimoteur ;
Proprioception

Résumé
Objectifs de l'étude. — Cette étude s'intéresse à l'effet de la fréquence du mouvement sur le couplage entre les signaux corticaux magnétoencéphalographiques (MEG) et la cinématique de mouvements des doigts répétitifs et volontaires ; c'est-à-dire la cohérence corticocinématique (CKC).
Matériel et méthodes. — La CKC a été calculée chez 10 adultes droitiers sains ayant exécuté des mouvements répétitifs de flexion/extension des doigts de la main droite dans trois conditions de fréquence de mouvements : *slow* (∼1 Hz), *medium* (∼2 Hz) et *fast* (∼3 Hz). Les signaux neuromagnétiques ont été enregistrés avec une MEG (Elekta Oy) et l'accélération de l'index droit par un accéléromètre. L'estimation des sources cohérentes a été effectuée en utilisant le modèle de dipôles de courants équivalents (DCE).
Résultats. — Des niveaux significatifs de cohérence ont été trouvés à la fréquence du mouvement ou à sa première harmonique chez tous les sujets et dans toutes les conditions de mouvement. Les sources cohérentes étaient toutes situées dans le cortex sensorimoteur primaire controlatéral à la main exécutant les mouvements. La fréquence de mouvement n'a pas eu d'effet significatif sur les niveaux de cohérence ni sur la localisation des sources cohérentes.
Conclusions. — Cette étude démontre que la fréquence de mouvement n'a pas d'impact sur le niveau de cohérence ni sur la localisation des sources de CKC pendant des mouvements volontaires des doigts. Ces résultats ont des implications directes pour la cartographie fonctionnelle préchirurgicale basée sur le CKC ainsi que sur les études s'intéressant à la physiopathologie des maladies du système nerveux affectant la voie proprioceptive.

Introduction

The corticokinematic coherence (CKC) quantifies the coupling between cortical activity and the kinematics of active [2] or passive [11] repetitive finger movements. Typically, CKC peaks at movement frequency (F0) and its first harmonics (F1) with the main neural source located at the primary sensorimotor (SM1) cortex contralateral to movements and at a location compatible with the known somatotopy [2]. CKC observed during passive finger movements is similar to that observed during active movements in terms of coherence level and source location [11], and directionality indices revealed that the coupling is considerably stronger in the afferent than in the efferent direction [5]. For these reasons, CKC is thought to mainly reflect movement-induced proprioceptive feedback [11,5]. The finding that CKC is visible at the individual subject level based on ∼3-min long recordings suggested that CKC is a robust method to locate the SM1 hand area (SM1ha) using magnetoencephalography (MEG) [2].

Previous CKC studies have used different rates of finger or hand movement (range: 1.2—4 Hz) [2—4,7,10,11,13]. All of them disclosed significant coherence at F0 or F1, which suggests that coherent frequencies are directly related to the movement rate. Still, it is unclear how the movement rate affects the coherence level and the main source location. A previous study demonstrates that passive index movements at 3, 6, and 12 Hz elicit similar CKC in terms of coherence level and source location [12], but whether this finding holds for active hand movements and at typical movement rates (i.e., below 3 Hz) has not been studied. Clarifying this issue has direct implications for clinical and research applications of CKC. Indeed, patients with motor deficits or movement disorders might struggle to perform fast repetitive finger movements. Allowing them to perform movements at a slower rate would foreseeably ease their task and reduce potential movement-induced artifacts in MEG data. Moreover, determining how the movement rate affects CKC is also mandatory for studies that will use this method to investigate the pathophysiology of brain disorders, as it would allow investigators to select the most appropriate movement rate.

The present MEG study assesses the impact of active movement rate (∼1 Hz, ∼2 Hz and ∼3 Hz) on coherence level and CKC source location.

Subjects and methods

Subjects

Ten healthy subjects (7 males; age range 24—40 years; mean age 31.1 years) without any history of neuropsychiatric disease or movement disorders were studied. All subjects were right-handed according to the Edinburgh handedness inventory [9]. They participated after written informed consent.