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Cortical Reorganization after Hand Immobilization: The beta qEEG Spectral Coherence Evidences

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Abstract

There is increasing evidence that hand immobilization is associated with various changes in the brain. Indeed, beta band coherence is strongly related to motor act and sensitive stimuli. In this study we investigate the electrophysiological and cortical changes that occur when subjects are submitted to hand immobilization. We hypothesized that beta coherence oscillations act as a mechanism underlying inter- and intra-hemispheric changes. As a methodology for our study fifteen healthy individuals between the ages of 20 and 30 years were subjected to a right index finger task before and after hand immobilization while their brain activity pattern was recorded using quantitative electroencephalography. This analysis revealed that hand immobilization caused changes in frontal, central and parietal areas of the brain. The main findings showed a lower beta-2 band in frontal regions and greater cortical activity in central and parietal areas. In summary, the coherence increased in the frontal, central and parietal cortex, due to hand immobilization and it adjusted the brains functioning, which had been disrupted by the procedure. Moreover, the brain adaptation upon hand immobilization of the subjects involved inter- and intra-hemispheric changes.

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Introduction

During their lifetime, human beings are highly likely to suffer accidents that can provoke hand immobilization (HI), which may temporarily or permanently impair the hand movements, and consequently, may induce changes in the cortical organization [1], [2], [3], [4], [5], [6], [7]. In particular, changes appear in the primary somatosensory cortex and primary motor areas (M1) in response to alterations of the hand conditions [8], [9]. In this study we investigate the cortical changes occurring after HI. For this purpose, we applied quantitative electroencephalography (qEEG), which has been proven to be a useful tool to examine cortical changes after limb immobilization [10], [11]. Specifically, qEEG can be employed to observe electro-cortical alterations produced by HI of the subjects right hand [11], [12]., We used coherence measures on beta band (β) (12 to 30Hz) which has been related to pre-motor and motor cortical regions during movement, attention tasks and cognitive functions in general [13], [14].

In addition, coherence measures estimates the coupling between two cortical areas that is suitable to observe changes during a sensorimotor task [15], [16]. A coherence decrease appears to act as a neural tracer of implicit memory (i.e., motor procedures) [16]. For this reason, in our experiment we used coherence to examine beta bands on the prefrontal and premotor scalp areas that are associated with motivation, planning and motor programming (F3-FZ/F4-FZ/F3-F4). In addition, we observed electrodes derivation which represent in prefrontal and premotor areas (F3/F4, F3/FZ, F4/FZ and F7/F8), motor cortex (C3/C4, C3/CZ and C4/CZ), parietal areas (P3/P4, P3/PZ and P4/PZ) and finally, secondary motor areas (T3/F7, T4/F8, T3/T4 and T5/T6). Here, we hypothesized that greater coupling occurs within inter- and intra-hemispheric cortical areas due to a new motor planning and sensorimotor integration to execute motor acts after hand immobilization.