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Research report

Lateralized asymmetries in distribution of muscular evoked responses: An evidence of specialized motor control over an intrinsic hand muscle

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ABSTRACT

Lateralized neural control over hand muscles has been associated with anatomical and physiological asymmetries in the central nervous system. Some studies suggested that the dominant cerebral hemisphere exhibit larger cortical representation areas with lower excitability, while others reported higher cortical excitability in dominant side compared to the contralateral, or even could not find any differences. Thus, neurophysiological lateral asymmetries are still controversial. This study aimed to evaluate differences in dominant and non-dominant sides in motor evoked potentials (MEPs) distribution and investigate whether conventional montages and high-density surface electromyography (HD-sEMG) provide reliable measurements of corticospinal excitability. MEPs elicited by transcranial magnetic stimulation (TMS) were recorded from dominant and non-dominant sides of healthy right-handed participants with an electrode grid over the *abductor pollicis brevis* muscle. MEPs amplitude distribution, amplitude, latency and resting motor threshold (MT) were evaluated. MEPs distribution significantly shifted towards the lateral direction on the dominant side. MT, amplitude, and latency did not reveal any asymmetries in functional cortical excitability. MEPs amplitude and latency were different for conventional montages and HD-sEMG. Our results suggest that laterality asymmetries manifest in both levels of cortical representation and muscle recruitment, possibly leading to a more pronounced abduction movement on dominant hemisphere compared to the non-dominant side in right-handers. Furthermore, the use of HD-sEMG provided additional insights over conventional electrode montages. A better understanding of laterality asymmetries in fine motor control may help to establish specialized treatments in sensory motor disorders patients.

1. Introduction

The phenomenon of manual laterality or handedness is usually defined as the hand preference to perform unilateral motor tasks. Handedness manifests itself in everyday activities, from merely grasping an object to more sophisticated tasks as handling a musical instrument. Lateralized neural control over hand muscles has been associated with anatomical and physiological asymmetries in the central nervous system. Dominant hemisphere of right-handed subjects may have higher corticospinal tract density (Kertesz and Geschwind, 1971; Nathan et al., 1990). Some authors suggested that the dominant brain hemisphere exhibit larger cortical representation areas with lower excitability (Triggs et al., 1999; Wassermann et al., 1992). In contrast, others reported higher cortical excitability in dominant cerebral hemisphere compared to the contralateral side (Macdonell et al., 1991; Triggs et al., 1994) or even could not find any difference between them (Davidson and Tremblay, 2013; Ferron and Tremblay, 2017; Shibuya et al., 2017; Triggs et al., 1999). Thus, neurophysiological assessment of handedness is still controversial.

Abbreviations: APB, *abductor pollicis brevis*; EMG, electromyography; HD-sEMG, high-density surface electromyography; M1, primary motor cortex; MEPs, motor evoked potentials; MT, motor threshold; TMS, transcranial magnetic stimulation.

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Transcranial magnetic stimulation (TMS) has been used as a valuable tool to study some neurophysiological markers related to laterality. The possibility of non-invasively activate the primary motor cortex (M1) and measure motor evoked potentials (MEPs) provide information about the level of cortical excitability, cortical motor representation area and level of muscle recruitment from both dominant and non-dominant cerebral hemispheres. Even though TMS can be considered as a focal stimulation, it activates a cortical area of about 1 cm^2 and it is more likely to stimulate an underlying neuronal circuitry connected to a group of related muscles rather than evoking the response of one in particular (Classen et al., 1998; Hammond, 2002; van Elswijk et al., 2008). Activation of a group of muscles becomes evident when looking at the spatial distribution of MEPs recorded with high-density surface electromyography (HD-sEMG). Mapping the forearm muscle recruitment by TMS might indicate possible activation of surrounding muscles and provide different spatial distribution of MEPs depending on stimulation intensity (van Elswijk et al., 2008). In this sense, any anatomical or physiological lateral asymmetry underlying the complex neural-motor control may contribute to a possible distinct distribution of myoelectric activity. Moreover, previous studies on handedness recorded MEPs with conventional (~1 cm diameter) surface electromyography (EMG) electrodes in monopolar or bipolar montages. In this case, electrodes detect MEPs over a single, standard position, usually the muscle belly. If there are significant lateral asymmetries or different recruitment of surrounding muscles in dominant and non-dominant sides, using conventional electrodes may provide biased myoelectric responses (Gallina et al., 2017; Souza et al., 2017).

Therefore, this study aimed to evaluate possible asymmetries in muscle-evoked responses spatial distribution related to manual dominance. Additionally, we investigated whether HD-sEMG and conventional monopolar and bipolar montages provide reliable measurements of the cortical motor function while comparing dominant and non-dominant sides. Experimental procedures included the right and left cerebral hemispheres in right-handed subjects in an intrinsic hand muscle, the *abductor pollicis brevis* (APB).

2. Results

Centroids were extracted from the amplitude distribution maps as illustrated in Fig. 1 for a representative subject. There was no significant correlation between the extent of change in centroid coordinates and the laterality index ($r = -0.287$; $P = 0.454$). Additionally, the change in centroid coordinates showed no significant correlation with both amplitude ($r = -0.373$; $P = 0.323$) and latency ($r = 0.180$; $P = 0.644$) differences extracted from the cluster of electrodes. Centroids medial-lateral coordinates differed between each stimulation hemisphere, revealing more lateralized MEPs amplitudes distribution for dominant compared to non-dominant hand ($t = 4.602$; $df = 8$; $P = 0.002$; Fig. 1B). In turn, proximal-distal coordinates were similar for both stimulated cerebral hemispheres ($t = 0.353$; $df = 8$; $P = 0.094$; Fig. 1B), leading to centralized sites of activation in proximal-distal direction in dominant and non-dominant hands.

MEPs amplitude varied across different electrode montages (χ^2 (1) = 6.489; $P = 0.011$) but not for the stimulation side (χ^2 (1) = 0.270; $P = 0.603$). Amplitude was greater for cluster of electrodes compared to the bipolar montage by about 1.55 ± 0.65 mV (mean ± standard error; Fig. 2A). There was also a main effect of electrodes montage (χ^2 (1) = 23.435; $P < 0.001$) on MEPs latency, while no effect of stimulation side was found (χ^2 (1) = 1.231; $P = 0.267$). Latency was greater for conventional bipolar montage compared to the cluster of electrodes by 1.19 ± 0.45 ms (mean ± standard error) and to the conventional monopolar montage by 1.45 ± 0.45 ms (mean ± standard error; Fig. 2B). No statistical difference was identified for interaction between electrode montage and side of stimulation in MEPs amplitude (χ^2 (2) = 0.809; $P = 0.667$)

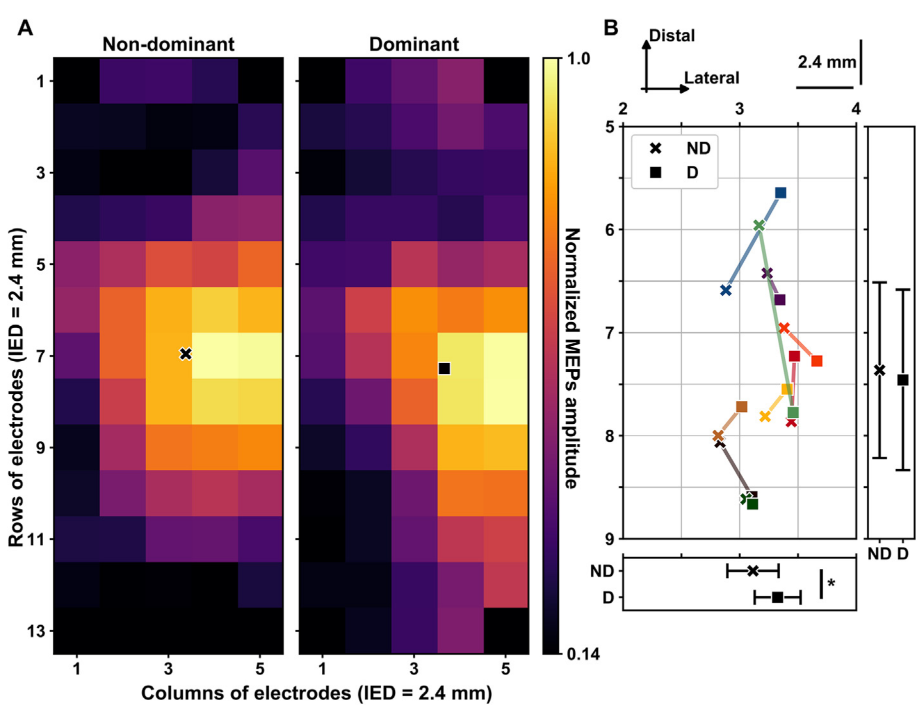

Fig. 1. MEPs amplitude distribution maps and plot of individuals' centroids for dominant (D) and non-dominant (ND) sides. **(A)** Scaled images created with peak-to-peak MEPs amplitude of a representative subject recorded for both sides. Amplitudes were normalized for visualization. **(B)** Centroids of amplitude distribution for each subject in dominant (■) and non-dominant (**X**) sides identified with a unique color and connected by a solid line (n = 9 subjects). Marginal boxplots show mean and standard deviation of coordinates in proximal-distal (right) and lateral-medial directions (inferior; * P = 0.002).