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論文名	The effect of tonic contraction of one hand muscle on motor area of tonically contracting another hand muscle 手指筋緊張性収縮が緊張性に収縮する隣接筋運動野表象へ及ぼす影響	
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論文要旨

Enslaving effect is the involuntary force production of the finger by force production of the other fingers. Moreover, force production of one finger decreases and cessation of force production of the same finger increases force production of the other fingers. Such interaction of motor outputs between the fingers must be partially mediated by neural interaction; i.e., horizontal interaction among the motor cortical cells. Indeed, inactivation of the motor cortical cells reduces independency of finger movements, indicating that the motor cortical cells contribute to balance between independent and coordinated finger movements.

Tonic contraction of the proximal arm muscle facilitates motor evoked potential (MEP) map in the distal arm muscle. As enslaving effect is, this interaction must be partially mediated by neural interaction through the horizontal connection of the motor cortical cells. In spite of this view, MEP in tonically contracting hand muscle elicited at the hotspot was not modulated by tonic contraction of the adjacent hand muscle. One of the explanations of the different findings between the studies on MEPs elicited across the MEP map and on MEPs elicited at the hotspot is that the motor cortical cells, which play a role for coordination of the hand muscles, are unequally distributed across the motor area,

and these cells are relatively sparse at the hotspot of the MEP. Indeed, the motor area of the MEP map, where prominent MEPs in a particular muscle are evoked, has certain extent. Accordingly, it is possible to suppose that certain area within the motor area other than the hotspot is interactive among the motor cortical cells mediating coordination between the hand muscles.

Movements of the different fingers partially share the functional somatotopy of the motor area. The overlapped area (OL area) of the motor area has been considered to play a role for coordination of finger movements, and the non-overlapped area (NOL area) of that plays a role for the independent movement. This hypothesis could be studied by use of the MEP map.

In the experiment 1, the effect of tonic contraction of the hand muscle on the motor area of the contracting adjacent muscle was examined. The map of the MEP in the first dorsal interosseous (FDI) and the abductor digit minimi (ADM) muscle were obtained with the participant at rest or during tonic contraction of the ADM muscle while the FDI muscle was tonically contracted. The center of gravity (COG) in the FDI muscle shifted medially during contraction of the ADM muscle. Motor area of the MEP map in the FDI muscle, non-overlapped with those in the ADM muscle, was suppressed by tonic contraction of the ADM muscle. In contrast, the motor areas of the MEP map in the FDI muscle, overlapped with those in the ADM muscle was not modulated by tonic contraction of the FDI muscle. It is concluded that medial shift of the COG of the MEP map in the contracting hand muscle induced by tonic contraction of the adjacent muscle must be due to suppression of the lateral motor area.

In the experiment 2, an investigation was made to elucidate whether the facilitatory and inhibitory circuits of the motor area of tonically contracting hand muscle is modulated by tonic contraction of the adjacent muscle. The map of the MEP and that of the cortical silent period (CSP) in tonically contracting hand muscle tested were obtained while the adjacent muscle was tonically contracting or was at rest. Motor area of the MEP map and that of the CSP map in the FDI muscle, non-overlapped with those in the ADM muscle, were suppressed by tonic contraction of the ADM muscle. In contrast, the motor areas of the MEP and CSP maps in the FDI muscle, overlapped with those in the ADM muscle, and those in the ADM muscle, both overlapped and non-overlapped with those in the FDI muscle, were not modulated by tonic contraction of the adjacent hand muscle. The centers of the non-overlapped areas of the MEP and CSP maps in the FDI muscle were lateral to those of the overlapped areas in the FDI muscle, and were lateral to both the overlapped and non-overlapped areas in the ADM muscle. In conclusion, the suppression observed in the present study may be caused by a fact that the lateral motor area of the FDI muscle, non-overlapped with the motor area of the ADM muscle, is particularly susceptible to

motor command to the ADM muscle, or may be to prevent isolated activity of the muscle for the independent hand, when acting together with the adjacent muscle as the synergist.

The suppression in motor area of tonically contracted hand muscle by tonic contraction of the adjacent hand muscle is area dependent and muscle specific. This is possibly caused by greater susceptibility of the facilitatory and inhibitory circuits in the lateral motor area of the FDI muscle to motor command to the ADM muscle, or by smaller susceptibility of the motor area in the FDI muscle, acting for the independent finger, so that isolated activity of the muscle is suppressed when the muscle acts together with the adjacent hand muscle as the synergist.

審査結果の要旨

本博士学位論文は、手指筋収縮中に他の手指筋が付加的に収縮した時に生じる運動野・皮質脊髄路興奮性の変化を観察したものである。第一実験においては、第一背側骨間筋（以下 FDI）の筋収縮時に小指外転筋（以下 ADM）の収縮を付加することにより、FDI の皮質脊髄路への投射が優勢な運動野を経頭蓋磁気刺激した場合に限り FDI の運動誘発電位（以下 MEP）は抑制を受けた。これに引き続き第二実験では、FDI 収縮中に ADM 収縮を付加する場合と ADM 収縮中に FDI 収縮を付加する場合における MEP と cortical silent period (CSP) を観察した。その結果、独立性が高い指の筋の収縮中に独立性の低い指の筋が収縮すると独立性の高い指に特化して活動する運動野領域との連関が強い皮質脊髄路と GABA 抑制性回路興奮性が低下することを確認し、これらより、共同筋活動時に独立性の高い指のみの活動を制御する運動野領域との連関が強い皮質脊髄路と GABA 抑制性回路興奮性が低下すると結論した。これら研究成果は博士学位を授与するに値するものと審査委員会では判定した。