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論　文　名	Tactile perception of right middle fingertip suppresses excitability of motor cortex supplying right first dorsal interosseous muscle （右中指表在知覚プロセスによる、右第一背側骨間筋支配一次運動野の抑制）
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学位論文の要旨

When movement, the motor system is modified by somatosensory feedback accompanying motor output. It is possible that the input pathway from the primary sensory cortex (S1) to the primary motor cortex (M1) is involved in the correction process of somatosensory feedback accompanying motor output. M1 likely receives somatosensory input directly or indirectly from S1. Suppression of corticospinal excitability induced by electrical stimulation of the mixed peripheral nerve may not only be brought by the afferent signals from the axons mediating the signals from the skin receptors but also by those carrying proprioception. The modulation of corticospinal excitability induced by the electrical stimulation of the finger may not be only caused by the stimulation of the skin receptors but also by the direct stimulation of the afferent nerve axons carrying the signals from the skin receptors.

There is somatotopic organization of finger representations in S1. Accordingly, we hypothesized that the tactile perception-induced modulation of M1 excitability is dependent on the finger stimulated because of the somatotopic organization of finger representations in S1. There is also somatotopic organization of finger representations in M1. The first dorsal interosseous muscle (FDI) is the prime mover of the index finger movement, and the abductor digiti minimi (ADM) is the prime mover of the little finger movement. Thus, representation supplying the FDI and that supplying the ADM must be at least partially different. Accordingly, the tactile sensation-induced modulation of M1 may be specific to the muscle tested because of the different representations for the intrinsic hand muscles in M1.

In the experiment 1, tactile stimulation was given to one of the five fingertips in the left or right hand, and transcranial magnetic stimulation eliciting motor evoked potential in the FDI or The ADM was given 200 ms after the onset of tactile stimulation. The corticospinal excitability of the FDI at rest was suppressed by the tactile stimulation of the right middle fingertip, but such suppression was absent for the other fingers stimulated and for the other muscle or hand tested. This indicates that excitability of the corticospinal pathway supplying the right FDI is modulated by the tactile perceptual process of the right middle fingertip. The present finding is first to show that tactile perception of the right middle finger suppresses corticospinal excitability of the right FDI.

In the experiment 2, the effect of mechanical tactile stimulation of the right fingertips on the F-waves of the right FDI was tested. The persistence and amplitude of the F-wave was not significantly influenced by tactile stimulation of the fingertip in the right hand. These findings indicate that tactile perception of the right middle fingertip suppresses excitability of the motor cortex supplying the right FDI at rest. There was no significant effect of fingertip stimulation on excitability of the F-wave, indicating that the suppression of corticospinal excitability in the FDI induced by tactile sensation of the middle fingertip observed in experiment 1 is not explained by the change in motoneuron excitability but by suppression of M1 excitability.

In the experiment 3, the change in the silent period (SP), the change in the time between the TMS onset and the offset of the EMG silence, reflects the change in excitability of the inhibitory interneurons in M1. Based on this, we examined whether excitability of the inhibitory interneurons in M1 supplying the right FDI is modulated by the mechanical tactile stimulation of the right middle fingertip through observing the SP. There was no significant difference in the SP between the two conditions. Corticospinal excitability of the right FDI was not suppressed by mechanical tactile stimulation of the right middle fingertip during tonic contraction of the FDI. This indicates that the tactile perception-induced modulation of corticospinal excitability is dependent on the presence of the motor execution process.

Surround inhibition plays a role in the process in that the systems around the active system are inactivated so that the active system works efficiently. The middle finger is the one neighboring the index finger. The FDI is the prime mover of the index finger flexion. Thus, the motor system moving the right index finger is the one surrounding sensorimotor system of the right middle finger stimulated. Accordingly, the present finding may be explained by the view that tactile perception of the finger suppresses the motor process of the prime mover for the finger neighboring the finger stimulated. Surround inhibition is not equivalent between the hand muscles. Thus, conflicting findings between the FDI and ADM observed in the present study can possibly be explained by muscle specificity of surround inhibition. Surround inhibition is the mechanism that suppresses the system which is not involved in the task to be completed. The tested muscle is not the one to be suppressed but the one to be activated during the voluntary contraction of the muscle. This means that the motor system of the contracting muscle is not the surround system but the

system to be activated, and thus the active motor system supplying the contracting muscle is not the target of surround inhibition. Thus, absence of the tactile perception-induced suppression of corticospinal excitability during voluntary contraction of the tested muscle may reflect the fact that M1 is the active system during tonic voluntary contraction of the tested muscle, and thus this active system is not the target of surround inhibition.

論文審査結果の要旨

小田仁志君は博士後期課程において、表在覚受容器からの求心性斉射が一次運動野興奮性に及ぼす影響を検証する研究を行った。振動刺激（機械刺激）を用いて手指表在覚を刺激し、それに対する第一背側骨間筋および小指外転筋の皮質脊髄路興奮性の変調を第一実験で検証した。その結果、中指刺激による第一背側骨間筋の皮質脊髄路興奮性の抑制が観察された。この抑制が一次運動野由来であることを確認するため、第二実験では中指刺激に対する運動ニューロン興奮性変調についてF波を用いて観察した。その結果、F波の中指刺激による変調は観察されなかったため、第一実験で観察された中指表在覚刺激による第一背側骨間筋の皮質脊髄路興奮性の抑制が、一次運動野の興奮性抑制に由来することが示唆された。第三実験では、中指刺激による第一背側骨間筋支配一次運動野興奮性の抑制が、抑制性介在ニューロンの興奮を伴うものであるか否かについて、silent periodを用いて検証した。その結果、silent periodには中指表在覚刺激による変調は観察されなかった。したがって、中指表在覚刺激による第一背側骨間筋支配一次運動野興奮性の抑制には抑制性介在ニューロンの興奮は関与しないものと考えられた。さらに、有効であった刺激指と一次運動野興奮性の変動を示した指の関係より、中指表在覚刺激による第一背側骨間筋支配一次運動野興奮性の抑制には周辺抑制が関与すると考察した。

これらの研究について小田君は博士論文にまとめた。本研究で得られた、手指表在覚由来の求心性斉射が特定の筋を支配する一次運動野の興奮性介在ニューロンを抑制するという結論には十分オリジナリティがあると考える。また、実験手法や検証した仮説にも妥当性があると評価した。これらを踏まえ、論文の質は博士学位を授与するに相当する水準にあると結論した。