Motor Control Characteristics of Muscle Force Release for External Assistance

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（外的アシストに対する筋脱力の運動調節の特性）

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論　文　内　容　の　要　旨

Human movements involve releasing muscle force, as well as generating force. The regulation of force release is used for precise motor output, and cooperative movement with the human force augmentation system may increase the chances of the regulation. The aim of this thesis was to explore the motor control characteristics of force release during isometric elbow flexion and to examine how they are associated with mechanical assistance and the simultaneous multi-joint movement. The main objectives were to investigate whether the motor performance and electromyography (EMG) responses of the biceps brachii (BB) and triceps brachii (TB) muscles change during force release under the conditions of (1) releasing duration and targeted magnitude, (2) mechanical assistance with external force perturbation, and (3) muscle contraction of the unassisted limb.

The motor performance of force variability and target overshoot and EMG amplitudes were examined in varying duration and step-down magnitude to address objective (1). The results of target overshoot and BB muscle activity showed that distinct control strategies are required according to the level of step-down magnitude with a relatively short releasing duration. Objective (2) was addressed by providing mechanical assistance in the middle of a trajectory tracking task. The results confirmed that those motor strategies are also used in cooperative movements, while force variability is reduced by mechanical assistance compared to non-assistance. Bilateral muscle contraction was involved to address objective (3), and the results showed that muscle contraction of the unassisted arm raises motor performance in the assisted arm at a cost of increased BB muscle activity.

In summary, this thesis demonstrated the impact of static control and external factors on the motor performance and corresponding EMG responses during the regulation of force release. Based on an in-depth analysis of the results, the current findings provide novel insights into motor control characteristics of force release. Specifically, a conservative motor strategy adopted in the process of greater force change and simultaneous muscle contraction of the unassisted limb may be associated with efficiency of the cooperation between human and assistive force.