ORGANIZED HINDLIMB MOTOR RESPONSES EVOKED BY INTRASPINAL MICROSTIMULATION

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Control of multi-joint motor behaviors is one of the premier challenges for motor system neural prostheses. Our working hypothesis is that electrical activation of spinal neural circuits, rather than direct activation of last-order motoneurons, will simplify generation of complex motor behaviors. The purpose of these experiments was to characterize the hindlimb motor responses evoked by intraspinal microstimulation. We measured the endpoint forces evoked by microstimulation of the lumbar spinal cord in cats anesthetized with alpha-chloralose or decerebrated. The femur was fixed and forces at the paw were measured in the sagittal plane at 9-12 endpoint locations. The forces were represented as a force field (FF) constructed by dividing the workspace into triangles and estimating the force vectors within a triangle by interpolation. The magnitude and direction of the endpoint forces evoked by microstimulation varied with the limb position. At some stimulation sites, the evoked FFs exhibited a point of convergence where the net endpoint force was zero. Electromyographic records indicated that the convergent fields were produced by co-activation of multiple muscles. Ipsilateral stimulation in the dorsal aspect of the cord evoked convergent flexion FFs, but extension FFs evoked by ipsilateral stimulation were not convergent. Conversely, contralateral stimulation in the dorsal aspect of the cord evoked convergent FFs, but flexion FFs evoked by contralateral stimulation were not convergent. FFs evoked by stimulation of motoneurons in the ventral spinal cord or by intramuscular stimulation of individual muscles were not convergent. These results indicate that microstimulation of the mammalian spinal cord can activate groups of muscles to produce organized motor responses at the limb's endpoint, and support the hypothesis that activation of spinal neural networks will simplify control of complex motor functions.