A TWO LAYER MODEL OF THE SPINAL LOCOMOTOR CPG: INSIGHTS FROM DELETIONS OF ACTIVITY DURING FICTIVE LOCOMOTION

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A computational model of the locomotor central pattern generator (CPG) in the mammalian spinal cord has been developed on the basis of a comprehensive analysis of the patterns of motoneuron activity occurring during fictive locomotion evoked by midbrain stimulation in decerebrate cats. Specifically, our analysis focused on "deletions", which are errors in the alternating rhythmic activity of flexor and extensor motoneurons that occur spontaneously during fictive locomotion. During deletions, the activity of agonist motoneurons (e.g., extensors) is missing for an integer number of cycles whereas the activity of antagonists becomes tonic or continues to be rhythmic. We concluded that the patterns of motoneuron activities observed during deletions could not be explained within the framework of existing CPG models, including the classical Brown-Lundberg "half-centre" model (HCM). Our model extends the HCM and is based on a two-level CPG consisting of a half-centre rhythm generator (RG) and a pattern formation circuitry (PF) with reciprocal inhibitory interactions between antagonistic groups of neurons at three levels (RG, PF and Ia interneurons). Each interneuron and motoneuron type in the model is represented by a population of 10-20 neurons modelled in the Hodgkin-Huxley style. The model realistically reproduces patterns of alternating rhythmic activity of flexor, extensor and bifunctional motoneuronal populations, as well as the dynamics of membrane potentials of individual motoneurons. In addition it can recreate the anomalous network behaviour seen during deletions in fictive locomotion including the maintenance of cycle period. The results of modelling provide a basis for functional identification of spinal cord interneurons involved in generation and control of the locomotor pattern in mammals.
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