Locomotion

Locomotion is a directional movement that enables someone or something to move from one location to another.

The significance of the spinal circuitry in controlling postural and locomotor functions largely re-emerged in the mid-1970s under the leadership of Sten Grillner, demonstrating key phenomena of "central pattern generator" and "fictive locomotion" with an evolutionary perspective. These concepts raised the question of how much function can be recovered after paralysis, given the intrinsic automaticity of spinal networks in injured and uninjured states in adults.

The canonical model of striatal function predicts that animal locomotion is associated with the opposing regulation of protein kinase A (PKA) in direct and indirect pathway striatal spiny projection neurons (SPNs) by dopamine. However, the precise dynamics of PKA in dorsolateral SPNs during locomotion remain to be determined. It is also unclear whether other neuromodulators are involved. Here we show that PKA activity in both types of SPNs is essential for normal locomotion. Using two-photon fluorescence lifetime imaging8-10 of a PKA sensor10 through gradient index lenses, we measured PKA activity within individual SPNs of the mouse dorsolateral striatum during locomotion. Consistent with the canonical view, dopamine activated PKA activity in direct pathway SPNs during locomotion through the dopamine D1 receptor. However, indirect pathway SPNs exhibited a greater increase in PKA activity, which was largely abolished through the blockade of adenosine A2A receptors. In agreement with these results, fibre photometry measurements of an adenosine sensor11 revealed an acute increase in extracellular adenosine during locomotion. Functionally, antagonism of dopamine or adenosine receptors resulted in distinct changes in SPN PKA activity, neuronal activity and locomotion. Together, our results suggest that acute adenosine accumulation interplays with dopamine release to orchestrate PKA activity in SPNs and proper striatal function during animal locomotion [1)]

A review explores biological mechanisms governing spinal control of movements such as posture and locomotion. They focused on concepts that have evolved from experiments performed over the past decade. Rather than a comprehensive review of the vast literature on the neural control of posture and locomotion, they focused on the various mechanisms underlying functional automaticity, and their clinical relevance.

They proposed that multiple combinations of sensory mechanoreceptors linked to proprioception generate an infinite number of different sensory ensembles, having species-specific meaning and extensive influence in controlling posture and locomotion. These sensory ensembles are translated as a probabilistic phenomenon into highly specific but indeterminate actions. Therefore, they opined that spinal translation of these ensembles in real-time plays a central role in the automaticity of motor control in individuals with and without severe neuromotor dysfunction [2)].

1)
Ma L, Day-Cooney J, Benavides OJ, Muniak MA, Qin M, Ding JB, Mao T, Zhong H. Locomotion activates PKA through dopamine and adenosine in striatal neurons. Nature. 2022 Nov 9. doi:

10.1038/s41586-022-05407-4. Epub ahead of print. PMID: 36352228.
2)

Edgerton VR, Gad P. Spinal automaticity of movement control and its role in recovering function after spinal injury. Expert Rev Neurother. 2022 Aug 31. doi: 10.1080/14737175.2022.2115359. Epub ahead of print. PMID: 36043398.