CHANGES IN ELECTROPHYSIOLOGICAL PROPERTIES OF MOUSE CA1 PYRAMIDAL NEURONS DURING EARLY POSTNATAL DEVELOPMENT

Emilija Kavalnytė[1], Kornelija Vitkutė[1], Daiva Dabkevičienė[1,2], Igor Nagula[1], Urtė Neniškytė[1,3], Aidas Alaburda[1]

[1]Institute of Biosciences, Life Sciences Center, Vilnius University, Vilnius, Lithuania
[2]National Cancer Institute, Vilnius, Lithuania
[3]VU-EMBL Partnership Institute, Life Sciences Center, Vilnius University, Vilnius, Lithuania
emilija.kavalnyte@gmc.stud.vu.lt

During the first weeks of postnatal development, neurons undergo morphological changes, and the number of ion channels in the membrane increases [1]. These changes affect neurons electrophysiological properties [2], which determine the ability to receive, process, and encode information. Most of the electrophysiological studies of hippocampal development have been performed with rats, and the electrophysiological maturation of mouse hippocampal CA1 pyramidal neurons remains unknown. Moreover, studies suggest that there are possible sex differences in brain development [3, 4], which may affect electrophysiological profiles as well. Our aim was to evaluate the electrophysiological properties of hippocampal CA1 pyramidal neurons during postnatal development in different sex mice.

Wild-type mice of different sexes and ages (5 to 21 postnatal days) were investigated in this study. Electrical activity of hippocampal CA1 pyramidal neurons in acute mouse brain slices was recorded using the patchclamp whole cell configuration method. From the recordings, passive and active membrane electrophysiological properties were evaluated.

Results of investigating passive membrane properties showed that during the first three postnatal weeks, in both females and males, the resting membrane potential of mice hippocampal CA1 pyramidal neurons did not change, while input resistance and membrane time constant decreased. There were changes in active properties as well: threshold of action potential hyperpolarized, width decreased and amplitude, maximal upstroke and downstroke velocities increased. Spike-frequency adaptation resulted in an increase of action potential width, a decrease of maximal upstroke and downstroke velocities, and a depolarization of the threshold in all age and sex groups. However, the changes of action potential width during spike-frequency adaptation became less pronounced with age.

In conclusion, our findings indicate that the passive and active electrophysiological properties of mouse hippocampal pyramidal neurons change during the first three weeks of postnatal development, resulting in a faster response to a stimulus and generation of action potential series of higher frequency. That may lead to more effective information processing in the mature brain.

[1] Moody, W. J., and Bosma, M. M. (2005). Ion channel development, spontaneous activity, and activity-dependent development in nerve and muscle cells. Physiological Reviews, 85(3), 883–941.

[2] Sanchez-Aguilera, A., Monedero, G., Colino, A., and Vicente-Torres, M. A. (2020). Development of Action Potential Waveform in Hippocampal CA1 Pyramidal Neurons. Neuroscience, 442, 151–167.

[3] Weinhard, L., Neniskyte, U., Vadisiute, A., di Bartolomei, G., Aygun, N., Riviere, L., Zonfrillo, F., Dymecki, S., and Gross, C. (2018). Sexual dimorphism of microglia and synapses during mouse postnatal development: Sexual Dimorphism in Microglia and Synapses. Developmental Neurobiology, 78(6), 618–626.

[4] Yagi, S., and Galea, L. A. M. (2019). Sex differences in hippocampal cognition and neurogenesis. Neuropsychopharmacology, 44(1), Article 1.