The skeletal muscles are controlled by nerve cells called motoneurons that are located within the spinal cord. These cells receive inputs from many nerve centers, translate it and produce instructions (patterns of discharges), which are transmit to the muscles. On the basis of such information muscle are able to perform contractions, which are a base of motor functions. Properties of both motoneurons and innervated muscles can be modified in a result of reduction or increase in physical activity. It has been shown that the decrease in physical activity can even lead to atrophy of muscle fibers while elevation of physical activity evoked by endurance training (running, cycling) leads to increased resistance of muscle to fatigue.

It was also demonstrated that the changes observed in muscle function are always preceded by changes in the properties of the motoneurons. For example, the endurance training produces changes in the properties of the cell membrane of the motor neurons that may mirror in changes of frequency of discharge patterns produced by motoneurones. As a result, the skeletal muscle are capable of performing rhythmic movement over a prolonged period of time without fatigue.

The main reason for undertaking this research is the fact that molecular factors (proteins) that allow the transformation of motoneuron properties after endurance training are unknown. Some reports indicate that plastic changes in motoneurons induce proteins from the neurotrophin family. Recent data suggests that the transformation of motoneuron properties after endurance training can be triggered by neurotrophins such as BDNF (brain-derived neurotrophic factor), GDNF (neurotrophic glial), NT3 (neurotrophin 3), NT4 (neurotrophin 4), nerve growth factor (NGF), whose concentration in peripheral blood and muscles increases after endurance exercise. Literature data indicate the importance of BDNF in the modulation of motoneurones properties, because it is produced by contracting skeletal muscles and then retrograde and trans-synaptically transported from the muscles to motoneurons, where it connects to TRK-B receptors and can modulate the action of ion channels, which causes chronic changes in the functional properties of motoneurons. In addition, the increase in the concentration of neurotrophins (BDNF, GDNF, NT-3, -4, IGF) after endurance training may enhance synaptogenesis leading to the reorganization of synaptic inputs into motoneurons, changing their functional properties, this way. Therefore, based on the available literature, we hypothesize that changes in the properties of spinal cord motoneurons after endurance training are triggered by the increase in BDNF, GDNF, NT-3, NT-4 and NGF concentrations that modulate the action of motoneuron ion channels and/or reorganize synaptic inputs for motoneurons.

The research will be conducted on an animal model (rat) and the first goal of the project is to clarify whether the low concentration of BDNF in the blood serum affects the functional features of spinal cord motoneurons. The second objective of the project is to clarify whether the increase in BDNF concentration in blood serum and hind limb muscles caused by 5-week treadmill training modifies the properties of the rat spinal motoneuron. The third goal of the project is to check whether changes in the concentration of neurotrophins (BDNF, GDNF, NT-3, -4, IGF) cause the reorganization of synaptic inputs into motoneurons.

The first part of the project (research goals 1 and 2) will show whether changes in BDNF concentration in blood plasma and skeletal muscles induce changes in electrophysiological properties of spinal cord motoneurons controlling the locomotion of hindlimb muscles in the rat by modulation of motoneuron ion channels. The second part of the project (research goal 3) will show if changes in the properties of spinal cord motoneurons occur through the reorganization of their synaptic inputs. This task will also allow to determine which of the studied neurotrophins (BDNF, GDNF, NT3, NT4, NGF) cause plastic changes of synapses after endurance training.

Proposed research: (1) will help to explain the molecular basis of motoneuron plasticity; (2) allow to understand the relationship between molecular and physiological phenomena underlying the physical activity; (3) broaden knowledge on the adaptation of motoneurons to changes in the concentration of neurotrophins in the blood serum and muscles that are associated with changes in the intensity of physical activity.