

POPULAR SCIENCE ABSTRACT

Skeletal muscles are composed of muscle fibers, which are activated by a specialized type of neurons (motoneurons), clustered in the spinal cord. The axons of motoneurons travel along nerves to reach target muscles, then branch within the muscle and stimulate muscle fibers to evoke the contraction. On the other hand, receptors located within a muscle send to the central nervous system signals about the stretch, the muscle length and the muscle force, making the feedback connection. The position of the body and limbs are controlled primarily by activity of muscle spindles, which are receptors of complex structure and function, located between the bundles of muscle fibers within layers of connective tissue. The sensory fibers from the muscle spindles, which provide feedback information, are involved in the stretch reflex, participating in the motor control. This is a monosynaptic reflex -sensory fibers from the muscle spindles have direct feedback connections to the motoneurons. The project concerns the key structures of the spinal cord and the muscle involved in motor control processes and constituting elements of the stretch reflex arc.

The study will be performed on a commonly used animal model (rat). The aim of the experiments is to fill a significant gap in knowledge on previously unexplored sex differences in terms of mechanisms of control of the muscle force by the motoneurons of the spinal cord and role of feedback information from the muscle receptors in these processes. Comparison of the results of independent research projects indicates many discrepancies and inconsistencies in relation to the same morphological or electrophysiological properties of neurons in animals of both sexes. In order to eliminate the influence of experimental conditions, strain, age, origin, and levels of daily physical activity of animals, the study will be carried out on adult rats, male and female, in the same experimental conditions, in homogeneous age groups, from the same breeding and of the same level of daily physical activity. We plan experiments on 90 animals (45 males and 45 females). Hypotheses, based on the pilot studies, assume that the gender differences are significant (1) with respect to the electrophysiological properties of motoneurons, determining, their excitability and pattern of generated impulses -which significantly affects the sex differences in mechanisms of the recruitment of motor units and the force development during muscle activity; (2) with respect to the structure and density of muscle spindles - which differentiates the role of these receptors in males and females in the feedback transmission of sensory information and in modulation of the activity of motoneurons; (3) with respect to the Ia monosynaptic input from primary endings in muscle spindles to motoneurons. The project consists of three research tasks: (1) investigation of the electrophysiological properties of the cell membrane of the spinal motoneurons innervating the medial gastrocnemius muscle (which is the model muscle in this type of experiments) -by intracellular stimulation and recording of electrical potentials directly from the motoneurons; (2) determination of the number, density, and morphology of muscle spindles in the same muscle -using histological methods and microscopic analysis of the fixed and stained sections of the muscle tissue; (3) intracellular recordings of electrical potentials evoked in motoneurons by stimulation of sensory fibers from the muscle spindles. Experiments in tasks 1 and 3 will be carried out under general anesthesia, in fully controlled conditions (artificial ventilation, monitoring of the body temperature, heart rate, and end-tidal CO₂).

The principal effect of the project will be publications in international scientific journals indexed in the international databases. The results of the planned study on the sex differences will be innovative because for the first time a systematic analysis of three elements of the reflex arc will be performed in males and females: (1) the electrophysiological properties of motor neurons; (2) the structure of muscle spindles (3) the sensory information from muscle spindles transmitted to the motoneurons in the spinal cord. The results of the planned experiments will bring new elements to the basic knowledge in the field of neurophysiology and kinesiology, and indirectly to biomechanics, rehabilitation, theory of sport and physical recreation. The project results will help us understand (at the level of single neurons, receptors and synaptic connections) a basis for different in male and female character of motor behavior and strategies of motor control. The project will also affect the potential solutions in the social aspect, by a possibility of transferring some of the hypotheses and observations on sex differences at the level of neurons and receptors to analysis of the motor control mechanisms in humans. This may have practical significance in planning the forms of physical activity and procedures during the rehabilitation of patients of both sexes, and in determining the training plans in athletes (men and women).