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POPULAR SCIENCE ABSTRACT

1. Research project objectives/ Research hypothesis

The project concerns the effects of the spinal cord polarization by using trans-spinal direct current stimulation (tsDCS), which mimics natural polarization processes within spinal neuronal networks. In the study we will investigate the influence of electrical fields surrounding active neurons on activation of neighboring neurons within the action of electrical fields. The aim of this research project on an animal model (rat) is to fill a significant gap in neurophysiology and kinesiology: there is insufficient understanding of the physiological mechanisms underlying polarization processes. The investigations envisaged in the project are designed to answer the questions on how tsDCS modifies the membrane properties and excitability of motoneurons and how it affects the characteristics of the rhythmic discharges of motoneurons. The basic premises justifying this research problem are the lack of data on the direct effect of the transspinal polarization on motoneuron properties, and the numerous literature discrepancies in the attempts to explain the physiological mechanisms of polarization processes. Hypotheses, based on the pilot study, assume that (1) externally applied electrical fields immediately modify the excitability threshold, alter the characteristics of motoneuron discharges, and direction of changes depends on the nature of polarization (cathodal vs. anodal); (2) changes in motoneuron properties in response to trans-spinal polarization last much longer than tsDCS stimulation; (3) long-term polarization will initiate adaptive mechanisms of motoneurons.

2. Research project methodology

Research will be conducted on adult male Wistar rats, under 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 130 animals. Immediate, short-term and long-term effects of the spinal cord polarization will be identified, resulting in a comprehensive picture of the physiological mechanisms underlying the effects of the spinal cord polarization. At each stage of the research, both cathodal and anodal polarization will be applied to determine whether the effects observed are polarity-dependent. The project consists of three research tasks: (1) Immediate effects of anodal and cathodal transspinal polarization during recording from a motoneuron; (2) Sustained effects of a single session of transspinal polarization on motoneuron properties; (3) Influence of long-term, repeated spinal cord polarization on motoneuron properties. Experiments in tasks 1-3 will be carried out in vivo, under general anesthesia, in fully controlled conditions (artificial ventilation, monitoring of the body temperature, heart rate, and end-tidal CO2). recording will be made from motoneurons innervating hind limb muscles, located in L4-L5 spinal segments. In task 3, we predict an additional control group, which will consist of rats not polarized, but subjected to all other procedures applied to animals from research groups.

3. Expected impact of the research project on the development of science, civilization and society

The principal effect of the project will be publications in international scientific journals indexed in the international databases (Thomson Reuters Web of Science). Changes in the level of activity of neuronal networks and the excitability of ascending and descending neuronal tracts under influence of electrical fields are currently the subject of extensive studies of clinicians and neurophysiologists in many research centers around the world. Polarization of neurons induced artificially by externally applied DC stimulation is a new neuromodulation method that has recently been used more and more frequently (despite many unknowns in terms of mechanisms and neuronal interactions in the spinal cord) in rehabilitation of patients after neurological injuries or as a supplement to physical training. The results of the planned study will be innovative: (1) for the first time they will answer the question of how changes in electrical fields induced by trans-spinal direct current stimulation (positive or negative) modulate the electrophysiological properties of the spinal motoneurons; (2) for the first time the long-term effects of polarization of the spinal cord will be investigated. The results of the planned experiments will bring new elements to the basic knowledge in the field of electrophysiology of motoneurons and kinesiology, and will contribute to setting standards for the use of trans-spinal polarization in medicine, rehabilitation and sport.