

POPULAR SCIENCE ABSTRACT

The research project revealed for the first time changes in the neuromuscular system resulting from a 5-week volitional weight-lifting training. The main purpose was to investigate how this training influences the cells controlling muscle contractions - motoneurons located in the spinal cord, and how contractile properties and mechanisms of force-regulation change under such circumstances for single motor units (the smallest functional units of skeletal muscles). The results of the project appeared to be consistent and significant with respect to explaining main directions, speed and persistence of adaptive changes in the neuromuscular system in response to altered physical activity.

The experiments were performed on four groups of adult Wistar male rats: two control sedentary groups and two trained groups. The weight-lifting exercises were performed in a custom-made exercise apparatus in which rats lifted the weights put on their shoulders while reaching food. The procedure of weight lifting consisted of two 30-min sessions daily, 5 days per week, for 5 weeks, with a progressively increasing load. The total amount of food was controlled for all groups.

The first series of acute electrophysiological experiments based on intracellular stimulation and recording from lumbar motoneurons innervating trained muscles. The results showed that adaptive changes in response to strength training are achieved early, before distinct muscle hypertrophy. They concerned changes in electrical membrane properties and changes in rhythmic firing of motoneurons controlling the muscles. The adaptations were observed both in fast and slow type motoneurons. The increased excitability of neurons and higher discharge frequencies allow the muscle to develop higher forces during voluntary activity.

The second series of electrophysiological experiments based on functional isolation of single motor units - by electrical stimulation of single axons innervating the studied muscle. The results of these experiments revealed that most pronounced changes of contractile properties concerned fast-twitch, fatigue resistant and intermediate motor units. Their force increased and the twitch contraction time shortened; the shortening influenced the force-frequency relationship, a basic mechanism of motor unit force regulation. Moreover, fast-twitch, fatigue resistant units increased their ability to potentiate their force during rhythmic activity (the fatigue test). All these early functional changes were observed at the early stage of resistance training, in the absence of myosin transition or the upregulation of calcium-handling genes.

In summary, the observed adaptive changes in properties of motoneurons and motor units to a resistance training are multidirectional and specific for motor unit types. The results are significant for studies of training effects in humans, as they explain basic mechanisms of adaptation in training (including early adaptive changes of motoneurons), and indicate that they depend not only on the training intensity but also on the initial muscle structure (proportional contribution of the of motor unit types).