The following distinguishing features of the structure of the juxtaelectrode tissue in this case can be recognized: first, a reduction in thickness of the capsule covering the electrode tip by 2-3 times, second, the presence of a juxtaelectrode zone, rich in the liquid component of the ground substance, and third, the formation of a powerfully developed root of the capsule, penetrating into the substance of the myocardium. The reduction in thickness of the capsule covering the tip, and the formation of a juxtaelectrode zone with a marked trophic function are factors lowering the threshold of CP. Meanwhile a developed capsule of the neck and body determined the mechanical stability of the electrode.

It can be concluded that juxtaelectrode zone and the powerful root, penetrating into the myocardium, constitute a kind of artificial conducting system, permitting generalized spreading of excitation.

The conditions of this experiment and the results of the histological investigation indicate a practical way of reducing energy consumption during continuous CP: the use of porous carbon electrodes with a small area of stimulating surface and the use of stimulating pulses of alternating polarity, with the lowest possible (i.e., threshold) level of energy. These recommendations are in agreement with the conclusions of other researchers.

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ULTRASTRUCTURAL CHANGES IN RED MUSCLE FIBERS OF THE RAT QUADRICEPS FEMORIS MUSCLE DURING INCREASED MOTOR ACTIVITY

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KEY WORDS: physical exercise; ultrastructure; skeletal muscle.

When a muscle contracts it undergoes partial destruction. So that this destruction is not total as a result of prolonged working efforts, a repair mechanism must operate in it [10-13]. It has been shown experimentally that under conditions of acute physical strain, marked destructive changes are present at the ultrastructural level in skeletal muscle fibers [4, 7, 15]. The aim of this investigation was to examine, in experiments on animals, the action of prolonged and increasing physical exertion on the ultrastructural organization of muscle fibers of one type, namely red muscle fibers (RMF).

EXPERIMENTAL METHOD

Experiments were carried out an adult male Wistar albino rats aged 17 weeks, subjected to training exercises in the form of running on a treadmill, the track of which moved at a speed of 35 m/min. The animals were trained for 6 weeks in accordance with a definite scheme [14]. At the beginning of the experiment the duration of running was 10 min, and at its end, 60 min. Under general anesthesia 24 h after the end of the experiment pieces of muscle were removed from the red portion of the quadriceps femoris. Material was fixed by Palade's method in OsO_4. Ultrathin sections were stained with uranyl acetate and lead citrate and examined in the IEM-100C electron microscope.

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Fig. 1. Tubules of T system, sarcoplasmic reticulum, and mitochondria in muscle fiber of quadratus femoris (23,000×).

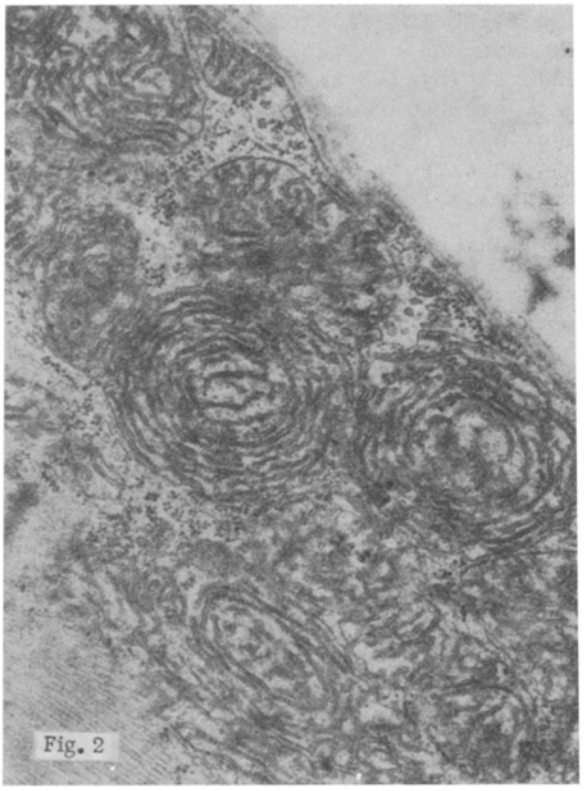

Fig. 2. Mitochondria with concentric cristae, short tubules of rough endoplasmic reticulum in peripheral zone of muscle fiber (19,090 ×).

EXPERIMENTAL RESULTS

During training of the animals for 6 weeks processes of a destructive character in RMF at the ultrastructural level consisted of dilatation of the terminal cisterns of the sarcoplasmic reticulum. Local dilatation of the tubules of the T system also was observed. Some tubules were filled with material of average electron density, and accumulations of amorphous electron-dense material appeared in the terminal cisterns of the sarcoplasmic reticulum; the structure of contacts of the T tubules with the terminal cisterns could not be identified (Fig. 1). Sometimes all three components of the triads were dilated. The mitochondrial apparatus of RMF showed considerable changes. Most mitochondria were characterized by a translucent matrix and a loose arrangement of the cristae; some mitochondria with concentric cristae were observed (Fig. 2). Partial destruction of the cristae was observed in some mitochondria, and sometimes they were completely destroyed and had undergone vacuolar degeneration. Occasionally focal destruction of myofibrils followed by their fragmentation were observed. Many primary and secondary lysosomes, autophagosomes, and multivesicular and residual bodies were observed in the peripheral sarcoplasm, and also in the interfibrillary sarcoplasm.

The presence of large concentrations of mitochondria beneath the plasma membrane of the muscle fibers was regarded as a type of repair process. The mitochondria were distinguished by great polymorphism. Interfibrillary mitochondria could form a branched network, and mitochondria with a dense matrix could be seen. Besides large mitochondria, small round mitochondria with single cristae also were present, and in some cases division of mitochondria along the cristae was observed. Short tubules of the rough endoplasmic reticulum, polysomes, and lamellar complexes were visible in the peripheral sarcoplasm. Beneath the basement membrane of the muscle fibers satellite myocytes were found at various stages of development. Most of them were large cells, stretched along the muscle fibers, and contained many organelles in their cytyplasm. These cells had a well developed ribosomal apparatus with many chains and rosettes of polysomes, a branched rough endoplasmic reticulum with dilated tubules, and a well-marked lamellar complex with membranous and vesicular components. Pinocytotic vesicles also were present in them. Multivesicular bodies and coated vesicles,

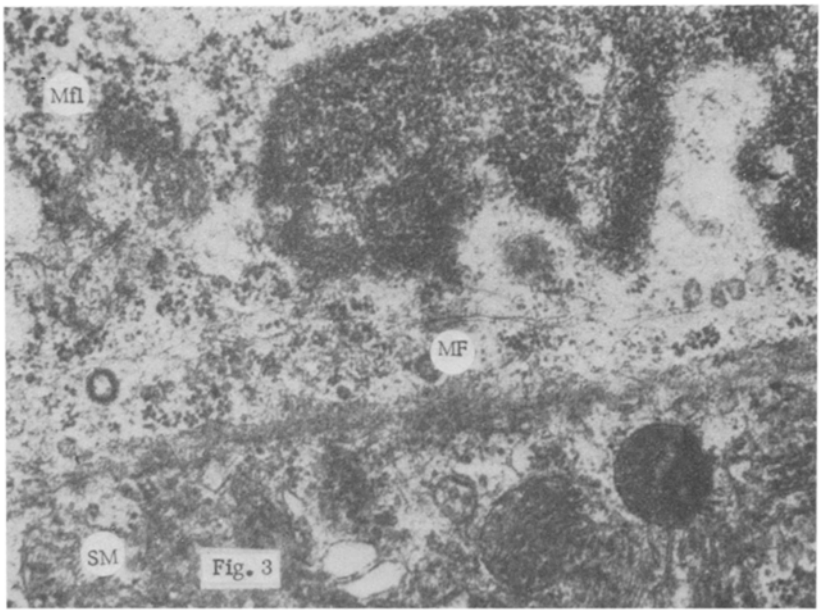

Fig. 3. Myofilaments in perinuclear zone of satellite myocyte (23,000 ×): MF) muscle fiber, SM) satellite myocyte, Mfl) myofilaments.

which also were found in the muscle fibers themselves close to the cells, were often seen in the satellite myocytes. On the free surface of the satellite myocytes, processes of other cells of similar type could be seen. In the perinuclear zone of the satellite myocytes short threads of myofilaments, grouped into small bundles, could often be seen (Fig. 3). Sometimes the distance between the plasma membranes of the satellite myocyte and muscle fiber was increased, and the basement membrane, separating structures that previously had been in topographic union, penetrated into the gap thus formed.

Signs of the strain experienced by the muscular system also could be seen in the blood vessels of the muscle. Capillary endotheliocytes were distinguished by their abundance of pinocytotic vesicles, connected with the luminal and basal surfaces of the cells, where vesicles were arranged in a row along the plasma membrane. The endotheliocytes had a pale matrix in which there were many vacuoles, free ribosomes, mitochondria, dilated tubules of the rough endoplasmic reticulum, a lamellar complex, and multivesicular and residual bodies; often one or two centrioles could be seen.

It can be concluded from a general review of the data that marked processes of partial utilization of structural components, accompanied by processes of physiological regeneration, take place in RMF of the quadriceps femoris muscle when functioning intensively under the experimental conditions. In the absence of, or in the presence of a very low intensity of physical work, it is difficult to identify the morphological picture of these processes. Dilatation of the tubules of the T system and of terminal cisterns of the sarcoplasmic reticulum is connected with intensive work of the muscle, and is probably reversible in character [8]. Mitochondria with a pale, swollen matrix and with fragmented cristae are regarded by some workers as evidence of predominance of destructive processes in the cells [1]. In the present experiments, however, besides mitochondria of this type, others with a denser matrix, and also small mitochondria were seen; division of the mitochondria could be observed, together with the formation of a large concentration of mitochondria beneath the plasmalemma of the muscle fibers, from which it can be concluded that a high intensity of synthetic processes was present in that particular structural apparatus of muscle fiber. Intensive development of the mitochondrial apparatus is evidently connected with the increased energy demands of the animal during active muscular exertion. The presence of a considerable number of lysosomes and their derivatives in the muscle fibers is probably a morphological expression of activation of the lysosomal system, which is responsible for the reconstruction of structural elements of any living functioning system when worn out [9]. The presence of myofilaments in the satellite cells and the tendency for some such cells to migrate into the interstitial space can be regarded as a process of conversion of satellite myocytes into myoblasts, i.e., as the beginning of myogenesis. The functional

state of the satellite myocytes is a reflection of the functional state of the muscle fibers [3], as the present investigation confirmed. The question of the origin of the satellite cells was not specially examined. Some workers [5, 6] who have studied athletes and also conducted experiments on animals after exhausting physical exertion, have observed the formation of satellite cells by separation of nucleo-sarcoplasmic territories from muscle fibers. However, the question of the genesis of satellite myocytes is not yet finally settled [2]. On the basis of the facts described above, relating to the development of destructive changes and of the repair reaction in a single muscle, in the writer's opinion the changes discovered in one section of the muscular apparatus probably reflect to some degree or other a response of the muscular system as a whole to intensified motor activity.

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ULTRASTRUCTURE OF HUMAN BLOOD T LYMPHOCYTES LABELED WITH MONOCLONAL ANTIBODIES*

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The introduction of monoclonal antibodies into immunologic practice has provided new opportunities for the exact detection of subclasses of lymphocytes carrying various membrane antigens and for the study of their submicroscopic organization as well as relations between the structure and function of lymphoid cells. The use of immunoelectronic microscopy, combining specific labeling of certain types of cells with ultrastructural analysis, is the most promising development in this respect. However, investigations of this kind have so far been only sporadic and fragmentary [4, 9].

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