RELATIONSHIP BETWEEN THE LEVEL OF POLARIZATION OF SKELETAL MUSCLE FIBERS AND THEIR TOTAL PROTEIN CONTENT IN YOUNG MATURE AND IMMATURE RATS

N. V. Darinskii and L. A. Siryk

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Changes in the total protein content, solid residue, and membrane potential of gastrocnemius muscle fibers were studied in mature and immature (with delayed development) rats aged from 3 to 30 days. In the immature rats, with lower body weight and temperature, a significantly reduced content of total protein and level of polarization of the skeletal muscles was observed than in mature rats of the same age.

Laboratory investigations have shown that physiological immaturity is characterized by mismatching of the physiological functions of the body which are specific for that particular period of chronological age [1-4, 8]. A deficiency in the supply of materials essential for functions in immature animals leads to delay in development and also to reduced powers of adaptation of the organism in response to the action of various stressors [3, 5-7].

The object of the investigation described below was to estimate the membrane potential (MP) of muscle fibers and to determine the content of solid residue and total protein in muscles of mature and immature rats in the early postnatal period.

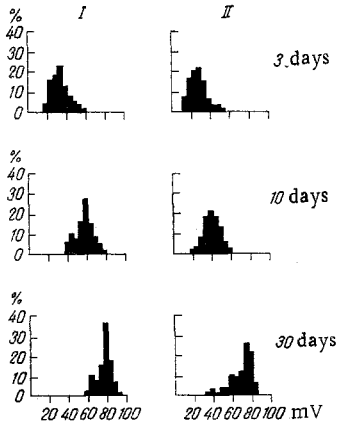

Fig. 1. Distribution of MP (in percent of total number of fibers measured) of gastrocnemius muscle of mature (I) and immature (II) rats aged 3, 10, and 30 days.

EXPERIMENTAL METHOD

Tests were carried out on 73 rats aged from 1 to 30 days. After birth the experimental rats were divided into two groups: physiologically mature and physiologically immature. The selection was based on physiological methods of diagnosis adopted in the author's laboratory [2, 4, 5, 8]. In this paper only 2 criteria of immaturity will be used: body weight and temperature (Table 1), which did not correspond to the rats' chronological age. At the ages of 1, 3, 7, 10, 14, 21, and 30 days the rats' body weight and temperature were determined. The MP of the gastrocnemius muscle, with its blood and nerve supply intact, was recorded by glass microelectrodes in the usual way [9, 10, 13]. Only stable (for 20-40 sec) values of MP were taken into account. After measurement of the MP the solid residue of the gastrocnemius muscle was determined by drying the wet tissue to constant weight, and the total protein concentration in the muscle was determined by the method of Lowry (1951).

EXPERIMENTAL RESULTS AND DISCUSSION

The results are shown in Table 1. The progressive increase in MP of the muscle fibers with age of the rats agreed with results obtained

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TABLE 1. Changes in Body Weight and Temperature, MP, Dry Residue, and Total Protein in Muscle of Mature and Immature Rats of Different Ages

Age (in days)	No. of animals		Body weight (in g)		Body temperature (in deg.)		No. of fibers tested		MP (in mV)		Solid residue (in percent)		Total protein in muscles (in mg %)	
mature	immature	mature	immature	mature	immature	mature	immature	mature	immature	mature	immature	mature	immature	mature	immature
3	3	7	8	6,6 ± 0,15	5,9 ± 0,17	33.6 ± 0,1	31,8 ±0,13	168	154	31,7 ± 0,80	25,8 ± 0,90	12,3 ± 0,31	11,8* ± 0,49	10,1 ± 0,44	8,3* ± 0,51
7	7	6	7	10,4 ± 0,36	8,7 ± 0,41	34,9 ±0,09	32,4 ±0,10	122	131	44,5 ± 1,18	38,1 ± 0,96	13,8 ± 0,54	12,4* ± 0,57	11,9 ± 0,61	8,9 ± 0,72
10	10	5	6	14,4 ± 0,67	11,4 ± 0,49	35,2 ±0,07	33,4 ±0,11	104	106	55,2 ± 1,21	42,6 ± 1,54	15,3 ± 0,66	13,6* ± 0,83	13,5 ± 1,03	10,4* ± 0,85
14	14	6	7	25,3 ± 0,85	17,4 ± 0,72	35,5 ±0,08	33,9 ±0,11	106	129	67,8 ± 0,94	50,2 ± 1,43	17,4 ± 0,64	14,7 ± 0,95	15,5 ± 0,77	11,6 ± 0,96
21	21	5	5	33,7 ± 0,85	24,6 ± 0,93	36,1 ±0,08	34,8 ±0,12	98	102	75,7 ± 0,65	69,1 ± 1,63	20,0 ± 0,48	16,1 ± 0,65	17,4 ± 0,63	13,2 ± 0,70
30	30	5	6	52,5 ± 0,63	42,5 ± 0,49	36,6 ±0,06	35,2 ±0,11	115	110	80,4 ± 0,41	75,1 ± 1,85	23,1 ± 0,39	19,7 ± 0,62	20,8 ± 0,32	16,9 ± 0,57

*P > 0.05; in all other cases P < 0.05.

by other workers [9-13], and in the mature rats at the age of 21-30 days it reached values close to the MP of the muscle fibers in adult rats (80-82 mV). The change in the level of muscle polarization in the mature animals took place against the background of a regular increase in the total protein concentration in the muscle, which also reached the adult level (20.8 mg%) by the age of 30 days. In the immature rats both the dry residue and the total protein concentration in the muscles were significantly lower (by 20-25%) than in the control rats of the same age. MP of the muscle fibers of the immature rats aged 10-14 days was 25% lower, and in rats aged 21-30 days it was 8% lower than in the mature rats. The low values of the dry residue and polarization level of the muscles in the immature rats at the age of 30 days can be regarded as evidence of a catelectrotonic syndrome in the muscles.

The distribution of MP (Fig. 1) showed the degree of its variability in the muscle at different age periods. For instance, whereas MP for the mature and immature rats aged 3 days varied within equal limits (15-60 mV), in the rats aged 10 days these limits differed sharply. Together with fully formed fibers with an MP of 60-80 mV, in the muscles of immature rats aged 30 days fibers with low values of MP (30-50 mV) were found, although they were absent in the muscles of mature rats of the same age.

Growth of muscle fibers in the early postnatal period can be explained, from the standpoint of the membrane theory, by an increase in the intracellular K concentration and also by a decrease in the ratio between the sodium permeability and potassium permeability of the membrane with age [9-11, 13]. According to another theory, which describes the MP with the aid of the surface potential between the living membrane and the external salt solution and with allowance for the density of fixed surface charges [12], growth of the MP of muscle fibers is largely determined by structural factors themselves depending on the activity of protein synthesis.

The gradual increase in the content of solid residue and the total protein concentration in the skeletal muscles of the mature rats is linked with corresponding changes in the physiological and physicochemical indices in these animals during early postnatal development, and it also correlates with changes in other systems and organs, thereby bringing about an increase in the working capacity of the organism as a whole [2, 8].

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