SOME BIOCHEMICAL CHARACTERISTICS OF SKELETAL MUSCLES OF RATS DEVELOPING UNDER CONDITIONS OF INCREASED MUSCULAR EXERTION AND OF HYPODYNAMIA

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UDC 612.766.1/.2-08:612.744

Biochemical characteristics of the tissues of rats developing under conditions of increased muscular exertion and hypodynamia (at temperatures of 20-22°C and 28-30°C) were studied. Exertion of the animals led to an increase in the mass of the skeletal muscles, accompanied by an increase in their content of protein, glycogen, ATP, and creatine phosphate and by a decrease in their lactic acid content. In rats developing under conditions of hypodynamia and supplementary heating, the opposite changes were found. Hypodynamia without heating caused no change in the energy and plastic resources of the body.
KEY WORDS: *hypodynamia; muscular exertion; postnatal development; energy resources; plastic resources.*

An increase in muscular exertion leads to economy both in the resting oxygen consumption and in the daily food requirement. The content of protein, glycogen, ATP, and creatine phosphate in the muscles increases, and so also does that of glycogen in the liver [1-5]. When muscular activity is restricted, the opposite changes might be supposed to take place.

In this investigation some biochemical characteristics of the skeletal muscles were compared in rats developing under conditions of hypodynamia and of increased skeletal muscular exertion.

EXPERIMENTAL METHOD

Male albino rats, 1 month old and weighing 50-52 g, were used in experiments lasting 6 months. Since hypodynamia requires keeping the animals in single cages, with tightly constricting walls, so that mutual warming of the rats is prevented and their heat loss is increased, the experiments with hypodynamia were carried out not only at room temperature of 20-22°C (group 1), at which the control rats were kept, but also at 28-30°C (group 2), close to the thermoneutral zone. The rats of group 3 ran on a flat treadmill for 10-60 min on alternate days. Control rats (group 4) were kept in ordinary cages. The animals were decapitated after superficial ether anesthesia. The hind limb was immediately fixed in liquid nitrogen. The protein content (by Lowry's method), DNA and RNA (by the method of Schmidt and Thannhauser), ATP, pyruvate, and lactic acid (after Meshkova and Severin), and creatine phosphate (after Alekseeva) were determined in the quadriceps femoris muscle. The glycogen level in the muscles and liver was determined by the anthrone method and the total lipid content gravimetrically. The absolute and relative values of the muscle mass also were determined and the contents of the various substances calculated in the whole tissue. The concentrations of protein, glucose, pyruvate, and lactate were determined in the blood of the rats at the time of sacrifice.

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TABLE 1. Biochemical Characteristics of Skeletal Muscles in Rats Developing under Different Conditions for Six Months (M±m)

Index studied	Experimental conditions			
	control (n=9)	exertion (n=10)	hypodynamia	
			20–22° (n=10)	28–30° (n=10)
Muscles:				
protein				
in g%	23,35±0,26	26,30±0,24	22,02±0,33	20,95±0,34
in g % (per whole tissue)	40,87±1,42	61,01±1,23	34,62±1,02	31,60±1,06
dry residue				
in g%	25,18±0,97	27,30±0,39	25,65±0,23	25,25±0,23
in g% (per whole tissue)	46,70±2,25	63,93±1,86	41,14±1,13	38,00±1,27
RNA				
in μg/g	1 092±80	1 226±11	1 046±41	1 512±74
in mg (per whole tissue)	226,9±21,1	296,2±10,5	187,1±13,8	225,7±6,3
DNA				
in μg/g	1 381±37	1 480±46	1 428±54	1 431±78
in mg (per whole tissue)	262,0±4,2	343±18	230±16	215±8
lipids				
in g%	17,76±0,80	17,17±0,69	19,80±2,48	18,60±0,98
in mg (per whole tissue)	8 263±378	11 102±352	8 175±598	6 287±210
glycogen				
in mg%	804±21	1 097±30	721±19	544±39
in mg (per whole tissue)	1 487±52	2 569±116	1 179±51	820±67
ATP				
in mg%	35,8±1,68	55,1±5,0	34,5±1,87	28,8±0,83
in mg (per whole tissue)	66,7±3,0	129,6±3,5	56,2±2,2	40,5±2,5
creatine phosphate				
in mg%	224,0±6,1	298,6±25,5	235,5±11,5	250,2±16,3
in mg (per whole tissue)	433±18	760±19	390±17	373±17
lactic acid				
in mg%	33,5±2,93	17,8±1,87	33,0±4,04	42,8±4,61
pyruvic acid				
in mg%	8,5±0,5	12,9±1,43	10,32±0,96	4,0±1,7
muscle mass				
in g	186,3±3,2	233,7±5,3	164,1±3,3	150,4±3,3
in % of body weight	40,6±0,5	45,0±0,8	38,2±0,6	41,4±1,1
Liver:				
glycogen				
in mg%	5 957±415	8 324±243	4 556±314	2 469±275
in mg (per whole tissue)	923±41	1 327±103	650±66	255±34
Lipids				
in g%	23,1±0,44	24,7±0,27	19,60±1,34	14,80±0,77
in mg (per whole tissue)	1 053±46	1 000±69	796±70	463±27
Total content in muscles and liver:				
glycogen				
in mg	2 410±86	3 896±117	1 849±75	1 117±70
lipids				
in mg	9 316±280	12 102±290	8 971±420	6 750±180
Weight of intraperitoneal lipids				
in mg	6 189±167	5 127±373	5 987±918	3 717±471
in % of body weight	1,23±0,11	0,97±0,06	1,37±0,22	1,04±0,15

Legend. Concentration of lipids in muscles and liver calculated per dry weight of tissue; all other indices calculated per wet weight of tissue.

TABLE 2. Blood Biochemical Indices for Rats Developing under Different Conditions for Six Months (M±m)

Index studied	Experimental conditions			
	control (n=9)	exertion (n=10)	hypodynamia	
			20–22°	28–30°
Protein (g %)	7,50±0,05	8,98±0,07	6,94±0,06	6,89±0,03
Glucose (mg %)	81,8±3,9	53,0±2,2	90,0±8,1	60,6±3,9
Lactate (mg %)	11,9±1,3	6,8±0,5	13,35±1,7	21,1±2,5
Pyruvate (mg %)	1,22±0,25	1,79±0,18	1,32±0,12	1,69±0,22
Lactate/pyruvate	9,1	3,8	10,0	12,8

EXPERIMENTAL RESULTS

It will be clear from the results given in Table 1 that the RNA and DNA concentrations in the muscles of rats developing under conditions of increased muscular exertion were a little higher than in the control. This could indicate increased synthesis of muscle proteins, more especially because the protein concentration in the muscles of the animals of this group was higher than in the control. Both the absolute and the relative weight of the muscle mass in these animals was much greater than in the controls. In rats developing under conditions of hypodynamia at 28-30°C the RNA concentration was 39% higher than in the control. However, since the concentration of muscle protein in these animals was lower than in the control it can be concluded that even the increased protein synthesis in these animals failed to keep pace with the rate of its breakdown in the muscles.

The total content of lipids in the muscles of the trained rats was rather higher than in the control animals, but purely because of the increase in mass of the muscle tissue. The total lipid content in the tissues of rats developing under hypodynamic conditions at 28-30°C was considerably lower than in the control. In the trained animals the total glycogen content in the tissues also was higher than the control, whereas in rats with hypodynamia it was reduced by almost half. Comparison of the results in Tables 1 and 2 shows that the increased muscular activity led to a higher ATP content but to a decrease in the lactic acid concentration in the tissues and blood. Restriction of activity, on the other hand, led to the opposite changes. The blood glucose level fell in all the experimental animals, but in the trained rats this was combined with high reserves, and in the animals with hypodynamia, with low reserves of liver glycogen.

Development of animals under conditions of increased muscular activity thus leads to an increase in the energy and plastic resources of the body. Hypodynamia is accompanied by changes in the opposite direction: Animals using less energy for motion and also, evidently, for maintaining the body temperature, have reduced energy and plastic resources.

Differences between the control animals and rats developing under conditions of hypodynamia without extra heating were negligible. The reason is probably that hypodynamia and cooling have opposite effects on metabolism.

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