CHARACTERISTICS OF ENERGY EXPENDITURE OF RABBITS AT DIFFERENT AGE PERIODS

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It is generally held that the changes in the activity of the cardiovascular system (cardiac rhythm and minute volume) and respiratory system (rhythm of respiration and pulmonary ventilation) in the process of postnatal ontogenesis are the result of the surface rule of energy [1, 2, 4-6].

Comparatively few reports of investigations of the energy expenditure in rabbits at different age periods were found in the literature [10, 11]. The investigations which have been carried out suggest only a tendency for changes to occur in the energy expenditure in the process of postnatal ontogenesis, but they do not allow their differences from one age period to another to be assessed.

The object of the present investigation was to study the changes in the oxygen utilization of rabbits at different age periods, when calculated both per unit of body weight and per unit of body surface.

EXPERIMENTAL METHOD

The energy expenditure was measured in a respiration apparatus using the method described by Grad [13]. The method has been described more fully earlier [12].

The investigations were carried out in a respiration chamber at a temperature of 19-22°, i.e., close to the temperature at which experimental animals are kept in the nursery. With a disturbance of the natural conditions of keeping, newborn animals of the type that are immature at birth cannot maintain their normal body temperature. For this reason, during the experiment, for the first days of postnatal life the animals were placed in a respiration chamber in specially built "nests" of cotton wool. The rectal temperature of the animal was measured before and after the experiment by means of an electrothermometer. The body surface [5] was calculated by May's formula:

$$S = K \cdot W^{2/3},$$

where W is the weight, and K a coefficient equal to 9.7 for rabbits. Preliminary investigations were carried out to study the specific features of the physiology of rabbits in the early age periods, which must be taken into consideration in the analysis of the changes in their pattern of gas exchange.

Experiments were conducted on 216 rabbits starting on the 1st day of postnatal life. The experimental results were analyzed by a ranking method.

EXPERIMENTAL RESULTS

In the early age periods, especially during the first hours and days after birth, the quiet needed for determining the energy expenditure corresponding to the basal metabolic level was observed (in contrast to the situation in adult animals) only when the animals had been fed and when the conditions essential for the normal development of the rabbit were undisturbed.

The short periods of waking coincided with regular meals. If during one of the regular periods of excitation of the food center, the newborn animal failed to receive milk from its mother, restless movements were observed, so that the level of the oxygen demand was raised to a level unacceptable as normal. More prolonged deprivation of food led to a marked fall of body temperature and also of the energy expenditure, a sign of a disturbance of the heat regulation in the newborn organism. A specific feature of young rabbits fed on their mothers' milk is that, in contrast to the great majority of mammals, female rabbits feed their young not more often than once or twice a day.

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Changes in Body Temperature of Rabbits in Postnatal Ontogenesis

Age	Rectal temperature
1—5 days	34—36,4°
6—13 "	36,4—37,7°
14—29 "	37,2—38,2°
1—3 months	38,0—39,1°
Over 4 months	38,2—39,2°

Classes	Age					
	days				months	
	1-5	6-13	14-23	24-29	1-3	4 or over
285-294						
275-284						
265-274						
255-264						
245-254						
235-244						
225-234						
215-224						
205-214						
195-204						
185-194						
175-184						
165-174						
155-164						
145-154						
135-144						
125-134						
115-124						
105-114						
95-104						
85-94						
75-84						
65-74						
55-64						
No. of cases	47	62	40	16	33	26
M	273,8	202,2	150,0	130,6	85,1	69,3
m	±3,4	±2,0	±2,3	±2,4	±1,9	±0,8

Fig. 1. Changes in the value of the relative body surface in rats in postnatal ontogenesis (in m^2/ton).

Investigations conducted in recent years have shown that the regular supply of food is one of the most important thermoregulatory factors maintaining constancy of the body temperature and the corresponding level of energy expenditure at an early age [3, 18]. For this reason, to obtain acceptable normal values of the oxygen consumption corresponding to the state of rest specific of the early age, the young rabbits from the 1st to the 12th-13th day of life were taken for investigation after feeding and placed in the specially constructed nest of cotton wool in groups of 3-4 animals all of the same weight. In these conditions their body temperature fluctuated within the range 34-36.4°, falling during their stay in the respiration chamber by not more than 0.6° or not at all. By the 12th-13th day of postnatal development, the body of the young rabbit is covered by a visible cover of hair, and it was therefore no longer necessary to place them in the nest during the experiment. In these circumstances the body temperature remained unchanged during the experiment.

In papers describing earlier investigations no details are given of the conditions in which the gas exchange of the young rabbits was studied: the number of animals in the respiration chamber, their body temperature, its change during their stay in the chamber, and the time after feeding when the investigation was made. The table shows the changes in the body temperature of the rabbits at the different age periods. By the age of 1 month the limits of the variations of the body temperature of the young rabbits had become the same as in the adult animals. From the results obtained, five age groups could be distinguished (see table).

In the rabbits of the 1st and 2nd age groups, the level of the oxygen consumption was determined 2-3 h after taking food. The rabbits of the 3rd age group were used in the experiment 4-5 h after taking food, those of the 4th and 5th groups 12-14 h after their last meal.

The curve in Fig. 1 shows the changes in the value of the relative surface area. A gradual fall in the value of the relative surface area to the adult state can be seen. According to the law of body surface, changes in the level of oxygen consumption calculated per unit of body weight must accurately reflect the changes in the relative body surface, while the changes in the level of oxygen consumption calculated per unit of body surface must follow a horizontal line throughout the period of postnatal ontogenesis.

Curves showing the actual changes in the value of the oxygen consumption during postnatal development are given in Fig. 2a and b. It is clear that the curve of the change in oxygen consumption not only per unit weight (Fig. 2a), but also per unit body surface (Fig. 2b), did not obey the surface rule of energy. According to the experimental data given in Fig. 2a and b, besides the general features of similarity between the curves characterizing the changes in the value of the oxygen consumption per unit weight and per unit body surface, certain ill-defined quantitative differences were present. From birth, for instance, the level of oxygen consumption per unit body surface gradually increased, reaching a maximum at the time of adoption of a standing posture (2nd age group), coinciding with the time when several analyzer systems begin to function. The motor activity of the animals reaches its maximum at this period [8], and the highest cholinesterase activity of the skeletal muscles is observed in these rabbits [7]. According to I. A. Arshavskii [2], in young animals which have not yet learned to stand there is no energy expenditure corresponding to the basal metabolism of adults in a resting state 12-14 h after taking their last meal.

After the final assumption of the standing posture the value of the oxygen consumption fell, not only per unit of mass, but also per unit of body surface. From this age, according to I. A. Arshavskii [2], "rest" is organized in animals and energy expenditure corresponding to the level of the basal metabolism begins. From the age of 1 month, i.e., shortly before leaving the mother, the oxygen consumption per unit of body mass continues to fall

Classes	Age					
	days				months	
	1-5	6-13	14-23	24-29	1-3	4 or over
56-57						
54-55						
52-53						
50-51						
48-49						
46-47						
44-45						
42-43						
40-41						
38-39						
36-37						
34-35						
32-33						
30-31						
28-29						
26-27						
24-25						
22-23						
20-21						
18-19						
16-17						
14-15						
12-13						
10-11						
No. of cases	47	62	34	14	33	26
M	34,7	54,6	26,4	22,7	17,4	13,2
m	±0,6	±0,7	±0,6	±0,3	±0,3	±0,3

a

Classes	Age					
	days				months	
	1-5	6-13	14-23	24-29	1-3	4 or over
306-315						
296-305						
286-295						
276-285						
266-275						
256-265						
246-255						
236-245						
226-235						
216-225						
206-215						
196-205						
186-195						
176-185						
166-175						
156-165						
146-155						
136-145						
126-135						
116-125						
106-115						
No. of cases	47	62	34	14	33	26
M	120,2	233,5	221,5	161,8	165,9	181,0
m	±4,6	±3,8	±3,5	±5,0	±4,4	±4,3

b

Fig. 2. Changes in the value of the oxygen consumption (in ml/min) in rabbits in postnatal ontogenesis in an environmental temperature of 19-22°, calculated per unit of weight (in kg; a) and per unit body surface (in m^2; b).

progressively, while that expressed per unit of body surface increases again, although in a not very clear form. Quantitative differences can also be seen. For instance, starting with the period of adoption of the standing posture and continuing until the adult state, the level of oxygen consumption per unit of body mass falls by 76%, and that per unit of body surface falls by 23%. It might be supposed that the lower level of oxygen consumption in the young rabbits up to 13 days old, expressed both per unit of mass and per unit of body surface, is connected with their lower body temperature. However, starting with the 14th-15th day of life, the body temperature of the rabbits continues to rise (see table), yet the level of oxygen consumption per unit of mass and per unit of body surface begins to fall. It may be concluded from the results obtained that the changes in the value of the oxygen consumption in the process of postnatal ontogenesis, calculated both per unit of mass and per unit of body surface, do not obey the body surface rule of energy expenditure.

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