

NUTRITIONAL STATUS AND SPONTANEOUS LOCOMOTOR ACTIVITY IN THE RAT

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Abstract: A considerable amount of energy may be saved by lowering the spontaneous locomotor activity when energy intakes are reduced. The results of the present study in rats undernourished for a period of 21 or 60 days and subsequently fed *ad libitum* diet did not show any differences in activity when compared to their respective control groups, either during the undernourished periods or well fed states. Although this would mean that the rats are not economising energy on activity, it is probable that these rats with lower body weights are contributing to energy saving mechanism by reducing the cost of activity per se since the cost of activity and body weight are directly related.

Key words: undernutrition spontaneous locomotor activity energy expenditure

INTRODUCTION

Energy balance deals with the relationship between energy intake (EI) and energy expenditure (EE) and can be simply represented as Energy Intake = Energy Expenditure + Energy Storage (1). EE has three components: Basal metabolic rate, Thermogenesis and Physical activity (2). It has been well recognised, both in man and animals, that when the balance between EI and EE is disturbed by reducing EI, they make an attempt to maintain the equilibrium between the two by reducing EE (3, 4, 5).

Physical activity has two aspects. a) The spontaneous locomotor activity (SLMA), which includes activities such as sitting, walking, standing, etc. and b) the physical work capacity which denotes the ability to perform a standard task (6). We have previously reported that undernutrition in rats resulted in reduced body weight, diminished nonshivering thermogenesis and cold induced thermogenesis without alteration in basal metabolic rate. Most of these changes were reversible and were restored to levels comparable to control values following adequate nutritional rehabilitation (7, 8). However, the reports available on activity in

undernourished rats are conflicting (4, 6, 9, 10, 11, 12). The present work aims at investigating alterations, if any, in the SLMA of rats during undernutrition as well as subsequent *ad-libitum* feeding.

METHODS

Two grades of undernutrition was induced in the growing young rats of either sex as follows:

a) Undernutrition from birth to 21 days (UN grade I).

Inbred female Wistar rats were mated to litter in pairs. Rat pups born within 24 hours of each other were used and the litter size was made upto 16 to induce undernutrition for first 21 days before complete weaning. Litter size limited to 5 served as well fed controls (13). Subsequently, after 21 days, the undernourished rat pups as well as control animals had access to *ad-libitum* laboratory rat diet upto the time they were 180 days old. *Ad-libitum* food and water was provided to the lactating mothers during the preweaning 21 day period.

b) Undernutrition from birth to 60 days (UN grade II).

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Undernutrition in rat pups was induced from birth to 21 days as explained above. Subsequently undernutrition was continued upto 60 days of age by providing a restricted amount of pellet diet (about 2-3 g per day). Water was given ad-libitum. This technique was followed to achieve a body weight deficit of approximately 70-75% in the undernourished rats at 60 days as compared to well nourished controls. The undernourished rats had free access to food after withdrawing the diet restriction at 60 days.

Food : The pellet diet (Hindustan Lever, Bombay) provided 15 kJ energy per g, 20 g protein per 100g and 4g crude fibre per 100g.

Housing conditions : The animals were maintained at a room temperature of $25 \pm 2^\circ\text{C}$ and

were housed in polypropylene cages measuring $35 \times 25 \times 15$ cm. During the postweaning diet restricted period in the case of UN grade II, the experimental rats were maintained singly in each cage. When started on ad-libitum diet, the rats were placed in groups of 4-5 in each cage.

Measurement of SLMA : The SLMA was visually observed daily during the periods of undernutrition. This method was adopted since the animals were too small to be placed in the activity cage used in this study for the measurement of SLMA.

During the periods of ad-libitum feeding, SLMA of each rat from both experimental and control groups was quantified using a Leigh-Valley activity cage (made in USA) (Figure 1).

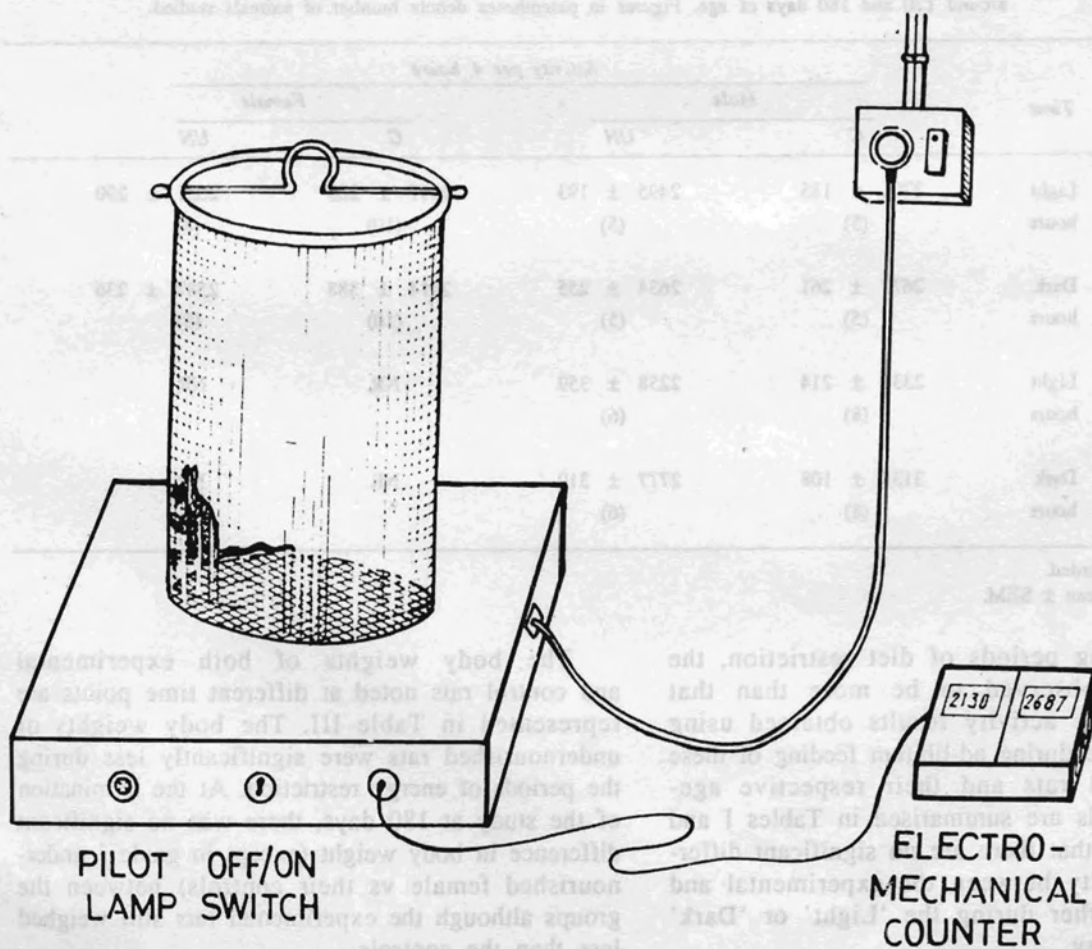


Fig. 1: A schematic diagram of Leigh-Valley activity cage used for the measurement of spontaneous locomotor activity in the rat.

The instrument consists of four infra-red detectors placed within a circular area of 1.6 m². It works on the principle that whenever the infra-red rays passing across the space are intercepted by the movement of the rat, it is recorded by an electro-mechanical counter. The numbers recorded are taken as a measure of SLMA of that rat.

SLMA was studied in one animal at a time (either experimental or control) when rats were about 120 and 180 days old. The activity measurement was made for a period of 4 hours each during the 'Light' and 'Dark' hours of the day (09.00 - 14.00 hr and 18.00 - 22.00 hr respectively). The activity of only the male rats was recorded at 180 days. The results obtained were

expressed as 'Activity per 4 hours'. Free food and water was provided to the rats during the recording of activity.

Values of SLMA and body weight are presented as Mean \pm SEM. Statistical significance of differences between the groups was determined by Student's unpaired t-test and values with $P < 0.05$ were considered statistically significant (14).

RESULTS

The SLMA observed visually during the energy restricted periods indicated that grade I undernourished rats displayed activity similar to control rats. However, in grade II undernourished rats, during

TABLE I : Spontaneous locomotor activity in grade I undernourished rats (UN) during ad-libitum feeding and their controls (C) around 120 and 180 days of age. Figures in parentheses denote number of animals studied.

Age in days	Time	Activity per 4 hours			
		Male		Female	
		C	UN	C	UN
120	Light hours	2701 \pm 185 (5)	2495 \pm 193 (5)	2417 \pm 285 (10)	2621 \pm 290 (8)
	Dark hours	2677 \pm 261 (5)	2634 \pm 255 (5)	2414 \pm 388 (10)	2587 \pm 236 (8)
180	Light hours	2336 \pm 214 (8)	2258 \pm 359 (6)	NR	NR
	Dark hours	3138 \pm 108 (8)	2777 \pm 319 (6)	NR	NR

NR - not recorded.
Values are Mean \pm SEM.

the postweaning periods of diet restriction, the activity was observed to be more than that in controls. The activity results obtained using the activity cage during ad-libitum feeding of these undernourished rats and their respective age-matched controls are summarised in Tables I and II which show that there are no significant differences in activity between the experimental and control rats either during the 'Light' or 'Dark' hours of the day.

The body weights of both experimental and control rats noted at different time points are represented in Table III. The body weights of undernourished rats were significantly less during the periods of energy restriction. At the termination of the study at 180 days, there was no significant difference in body weight (except in grade I undernourished female vs their controls) between the groups although the experimental rats still weighed less than the controls.

TABLE II : Spontaneous locomotor activity in grade II undernourished rats (UN) during ad-libitum feeding and their controls (C) around 120 and 180 days of age. Figures in parentheses denote number of animals studied.

Age in days	Time	Activity per 4 hours			
		Male		Female	
		C	UN	C	UN
120	Light hours	1754 ± 149 (6)	1706 ± 245 (6)	1803 ± 116 (6)	1750 ± 100 (6)
	Dark hours	1769 ± 206 (6)	2103 ± 186 (6)	1975 ± 158 (6)	2422 ± 154 (6)
180	Light hours	1741 ± 172 (5)	1701 ± 105 (5)	NR	NR
	Dark hours	1794 ± 200 (6)	1804 ± 140 (6)	NR	NR

NR - not recorded.
Values are Mean ± SEM.

TABLE III : Body weights of undernourished rats (UN) and their controls (C) at different time points during undernutrition and ad-libitum feeding. 'n', the number of animals is not shown in the table, but a minimum of 6 rats from each group was used in the study.

Age in days	Sex	Body weight (g)					
		UN grade I			UN Grade II		
		C	UN	% Deficit	C	UN	% Deficit
21	M	47.8 ± 1.6	22.4 ± 0.7*	53	45.0 ± 0.7	19.5 ± 0.4*	57
	F	44.7 ± 1.2	24.2 ± 1.2*	46	45.7 ± 0.8	21.1 ± 0.5*	54
60	M	160.7 ± 6.3	134.8 ± 4.1*†	16	180.4 ± 4.4	60.0 ± 1.5*	67
	F	136.1 ± 5.0	113.3 ± 2.9*†	17	139.6 ± 3.1	46.1 ± 2.1*	67
180	M	318.0 ± 11.9	291.4 ± 10.0*†	8	303.1 ± 8.8	283.9 ± 9.0†	6
	F	207.8 ± 3.7	177.3 ± 3.7*†	15	187.3 ± 4.8	181.4 ± 4.8†	3

M, Male; F, Female. *P<0.001. †Ad-libitum fed. Values are Mean ± SEM.

DISCUSSION

Energy conservation in undernourished states become essential for survival of the organism. It may occur in the form of a reduction in one or all

the components of energy expenditure. Several reports on voluntary activity during undernutrition both in man (15, 16) and animals (4, 6, 9, 10, 11, 12) have not given clear cut results despite the fact that SLMA utilises approximately 20% of daily

energy produced (1) and strong indications by some authors (3, 17) that small changes in activity can bring about energetic efficiency during energy restriction.

Although visual observation of activity cannot be relied upon to draw firm conclusions, it cannot be totally disregarded since such a method has been employed in some studies (11). The results obtained both during the periods of undernutrition (particularly in grade I undernourished rats) as well as during ad-libitum feeding show that these rats have similar pattern of activity as controls. The results suggest that the undernourished rats are not economising the energy by reducing the SLMA and may be using some other mechanism to save energy. However, while considering physical activity two aspects should be kept in mind, the number of movements or quantitative activity, and the energy cost of activity. Since the cost of activity is directly proportional to body weight and the rate of activity (18), the experimental animals are likely to spend less energy on daily activity since they weigh less than the controls. A similar view has

been put forward by James & Shetty (15) that in low body weight adult humans, the reduction in total energy expended on physical activity, even if activity is not reduced, may be a major mechanism of adaptation to total energy output per day.

Another finding in this study of an increased activity in grade II undernourished rats during the postweaning diet restriction may be a behavioural response to prolonged food deprivation.

Measurement of 24 hr activity would have been a better index to quantify activity in relation to nutritional status. However, this could not be done in the present study for technical reasons.

It may thus be concluded that energy conservation in undernourished rats is brought about at least partly by reducing the energy cost of activity rather than by lowering the amount of activity.

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