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ENERGY METABOLISM AND THERMAL SENSITIVITY OF KIDNEY CELLS FROM A HIBERNATOR *JACULUS ORIENTALIS* (A MOROCCAN DESERT RODENT)

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ملخــص

الاستهلاك الحراري الاساسي والحساسية الحرارية لخلايا الكلي عند حيوان مسبت *Jaculus orientalis* (من قوارض الصحراء المغربية).

إن استهلاك الأكسيجين في القشرة والحشوة الخارجية للكلى، في درجة حرارية تساوي 37 درجة مئوية لا يختلف عن النوع الصحراوي المسبت *Jaculus orientalis* والجرذان. أثناء الارتفاع الحراري التلقائي خلال السبات،يصل استهلاك الأكسجين إلى أقصاه بين 25 و 30 درجة مئوية مما يبين أن استهلاك الأكسيجين في شرائح القشرة والحشوة الخارجية للكلي لا يختلف بصورة بينة حسب درجة حرارة الحضانة، إلا بين 30 و 37 درجة مئوية. في حدود تلك الدرجات الحرارية يستهلك الأكسيجين عند النوع المسبت أقل من عند الجرذان وذلك في القشرة والحشوة الخارجية للكلي. هذه المعطيات تظهر تكييف الاستهلاك الأساسي على نطاق الخلايا.

SUMMARY

Oxygen consumption at 37°C of slices of renal cortex and external medulla is comparable in both a hibernating desert species *Jaculus orientalis* and in the rat. In the course of spontaneous elevation in rectal temperature during hibernation, oxygen consumption of the whole animal shows a maximum between 25 and 30°C, indicating maximal thermogenesis during this interval. Oxygen consumption values of renal cortex and external medulla as a function of incubation temperature were not significantly different except between 30 and 37°C. In this temperature interval the variation in oxygen consumption was much less in both renal zones in the hibernating species than in the rat. This indicates a metabolic adaptation at the cellular level.

RESUME

Metabolisme energētique et sensibilitē thermique des cellules renales d'un hibernant *Jaculus orientalis* (un rongeur du desert marocain). La consommation d'oxygène du cortex et de la medulla externe rénale à 37°C est identique chez l'espèce desertique hibernante *Jaculus orientalis* et chez le rat. Au cours du réchauffement spontané de l'hibernation, la consommation d'oxygène de l'animal passe par un maximum entre 25 et 30°C démontrant une thermogenèse maximale pendant cet intervalle de température. La consommation d'oxygène des coupes de cortex et de medulla externe du rein en fonction de la température d'incubation n'est pas significativement différente sauf entre 30 et 37°C. Dans cet intervalle de température la variation d'oxygène est plus faible dans les deux zones du rein chez l'espèce hibernante que le rat. Ces données indiquent une adaptation à l'échelle cellulaire du métabolisme.

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INTRODUCTION

During a long time it was unclear whether the energy requirement for the osmotic gradient during arousal from hibernation is provided by anaerobic glycolysis or by oxydative metabolism. HERMS and *al.* (1963), suggested on the basis of the anoxia conditions which prevail in the inner zone of the kidney and the decreased capacity to oxydise glucose which gradually decrease from cortex to papilla that the rebuilt of the corticomedullary gradient comes essentially from anaerobic glycolysis energy. In 1976, GUDER and *al.*, reported that oxydative metabolism of the inner zone of the kidney is not only notable but seems to be more involved in restoring osmotic gradients. In this conditions during arousal from hibernation, restablishment of Na^+ corticomedullary gradient which begin at 30°C (BADDOURI and *al.*, 1986) should reflect the intensity of oxydative metabolism during arousal.

The present study was designed to assess further this hypothesis and to examine the tolerance to cold of *Jaculus orientalis* cells kidney.

MATERIAL AND METHODS

MATERIAL

1 - Hibernation :

Before hibernation induction, animals were acclimated to 5°C during 4 to 5 weeks in climatic rooms equiped with a system of photoperiodism. At the time of induction which occurs between november and january, food was removed from animals. After 2 to 3 days animals were hibernating with a rectal temperature of 6°C. During rewarming, electromyograms were recorded on a multichannel recording instrument (Grass polygraph).

2 - Hypothermia :

Animals were cooled without the use of anesthetics or other pharmacological agents by means of the closed container technique (ANDJUS, 1956) to a rectal temperature of 6-7°C for jerboa and 15°C for rat (critical hypothermia temperature).

OXYGEN CONSUMPTION

On the body - Hibernating animal was maintained in a respiratory chamber at 22°C - The open circuit received a 2,5 l/min of dry air. Animal's expired air goes through the oxygen analysor (taylor) and the consumption was recorded by a physiograph (Grass instrument). Oxygen volume is calculated according DEPOCAS and *al.*, (1957).

Tissue oxygen consumption - Oxygen consumption was measured in the cortex and the outer medulla in six groups of animals with variable induced hypothermia (10-15-20-25-30-35°C) and one group with a rectal temperature of 37°C. For each measure, temperature of incubation of renal tissue and that of the animal rectum were similar during renal sampling.

Outer medulla and cortex were sliced to approximately 0,3 mm or less. Tissues (30 to 80 mg) were transferred to flasks containing 3 ml Krebs-Ringer solution, pH 7,4 with excess glucose (1 mg/ml). The central well of the flasks contained rolls of filter paper moistened with 0,3 ml of 10% KOH. The oxygen consumption was measured following procedure described by EL HILALI and *al.* (1978). For each tissue and temperature, 8 to 10 determinations were made using at least 4 to 5 animals.

RESULTS

For both species, the rates of oxygen consumption obtained at each of the test temperature (for the cortex and outer medulla) are given in table I. Between 10 to 30°C, hypothermia lowered significantly cortex and outer medulla metabolic rates ($p < 0,001$). In the hibernating species renal tissue oxygen consumption values determined between 30 and 37°C body temperature were not statistically different whereas for the same range of body temperature, values obtained for rat tissue varied significantly ($p < 0,001$).

	37°C	30°C	25°C	20°C	15°C	10°C
			Jaculus orientalis			
Cortex	2817 ± 103	2455 ± 211	1318 ± 98	969 ± 56	677 ± 33	550 ± 36
Externe medulla	2172 ± 217	1897 ± 83	1165 ± 149	960 ± 44	693 ± 82	535 ± 46
			Rat			
Cortex	3692 ± 130	2434 ± 164	1448 ± 38	819 ± 40	719 ± 72	
Externe medulla	2729 ± 149	2080 ± 77	1149 ± 39	733 ± 44	564 ± 23	

Table I : Oxygen consumption ($\mu l/h^{-1}/g^{-1}$ wet weight) in the cortex and outer medulla during rewarming from hypothermia.
Each plot is the mean of 9-10 data from 5 animals.

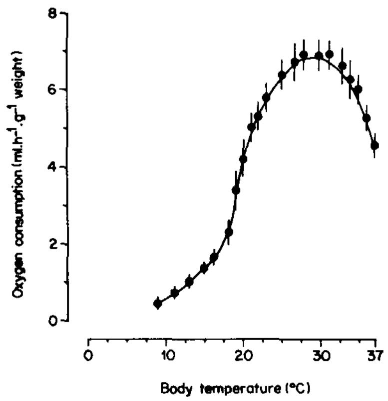

Figure 1 : Body oxygen consumption during rewarming from hibernation of *Jaculus orientalis*.
Each plot is the mean of 8 animals ± ESM.

At the time of rewarming, animal total metabolism (fig. 1) shows that starting 25°C, oxygen consumption of the animal reaches it's maximum (6.44 ml/h/g) and is maintained till 30°C (6,81ml/h/g). During this rewarming period, shiver thermogenesis appears at 22°C and reaches its maximum between 25 and 30°C (fig. 2). The ratio of the renal oxygen consumption and that of the entire animal varies around the value 1 at a temperature of 10°C and decreases with rewarming until about 25°C. Values between 30 and 37°C of the ratio show a returned renal metabolic activity (tabl. II).

DISCUSSION

The results of experiments showed in the range of 30-37°C body temperature a lesser variation oxygen consumption of renal tissue of *orientalis* than those from the rat. Similar data reported

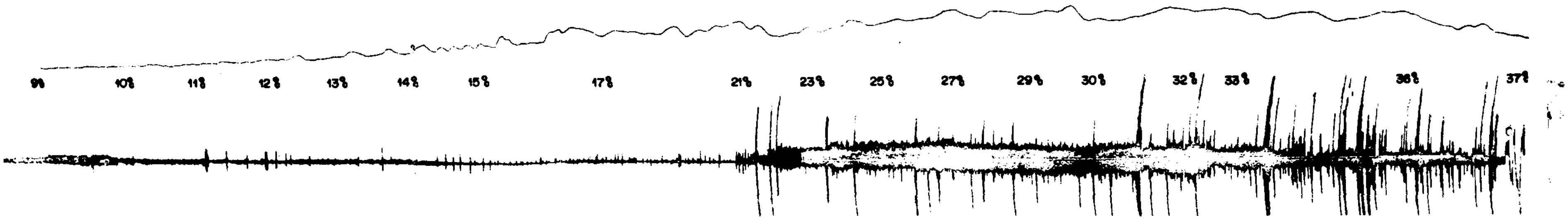

Figure 2 : Recording of oxygen consumption and electromyogram during rewarming from hibernation.
Numbers indicate rectal temperature of an animal during rewarming.

Table 2 : Ratio of tissue oxygen consumption and body oxygen consumption during rewarming.

	Qo_2 tissue / Qo_2 animal					
	10°C	15°C	20°C	25°C	30°C	37°C
Cortex	1	0,49	0,23	0,20	0,36	0,62
Externe medulla	0,96	0,50	0,23	0,18	0,28	0,48

by KAYSER (1954) stated higher metabolic rate of renal tissue from hibernation than from homeotherms. This species difference may not be attributed to a direct effect of lowring temperature but could be considered as the result of species adaptative change at the cellular level in the hibernating species (HORWITZ, 1964; ANDJUS and *al.*, 1974; EL HILALI and *al.*, 1978). Oxydative metabolism decreases during hibernation and hypothermia. However, renal concentration capacity is very closely related to renal oxydative metabolism particularly in the outer medulla which contains ascendant limbs of the Henle loop (WEINSTEIN and *al.*, 1969). But several investigators (WILLIS, 1968; ANDJUS and *al.*, 1971; RATHS and *al.*, 1976) showed that the anaerobic glycolysis would be more pronounced in hibernating compared to other mammals during torpor. Furthermore TORELLI and *al.*, (1973) have related the anaerobic glycolysis to sodium transport particularly during low temperatures. But according to GUDER and *al.*, (1976) energy produced from glucose degradation would be higher than from anaerobic glycolysis. At this state, since the large portion of renal O_2 consumption is utilized for active Na^+ reabsorption (LASSEN and *al.*, 1961) the corticomedullary sodium gradient returns to normal more efficiently in hibernating species than in the rat (BADDOURI and *al.*, 1986) indicating the importance of oxydative metabolism even at low temperature in hibernating species.

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