THE GLUCOSE TOLERANCE OF THE WEST AFRICAN DWARF GOATS

S. G. NAIR AND S. N. SHETTY

Department of Veterinary Physiology and Pharmacology,
University of Nigeria, Nsukka, Nigeria

(Received on November 20, 1980)

Summary: Glucose tolerance tests conducted on 4 adult goats and 3 kids, injecting glucose intravenously (0.5 *g/kg* body weight), showed that the former required 180 min and the latter 45 min after injection, to restore blood glucose to normal.

For the adult goats, the turnover rate (K) was 0.38 ± 0.03/hr, turnover time (T_T) 2.64 ± 0.18 hr and half-time ($T_{\frac{1}{2}}$) 110.24 ± 7.73 min for glucose clearance while for the kids, these were 1.59 ± 0.12/hr, 0.64 ± 0.04 hr and 26.05 ± 4.36 min respectively. The higher glucose clearance in the kids than in the adults may be attributed to a more efficient insulin response and to greater glucose utilization than in the former. The dwarf goats appear to differ substantially from the cows in their homeostatic responses to induced hyperglycemia.

Key words: goats glucose tolerance kids

INTRODUCTION

In ruminants, the central role played by acetate in their overall energy metabolism, relegate glucose to a secondary place in this respect. From the results of glucose tolerance tests conducted on normal and diabetic cows (8), Kaneko (7) concluded that the glucose tolerance of the cow is comparable to that of other animals, eventhough earlier studies indicated a decreased glucose tolerance in cows (4) and sheep (5,11,15). Hale and King (3) investigated the influence of ration on glucose tolerance of lambs. Edwards (2) compared glucose tolerance of new-born and 2-4 weeks old calves. Lend (9) reviewed studies on glucose entry rate and pool size in ruminants using isotope tracer techniques.

In goats, requirement for digestible nutrients per 100 lb body weight is twice as that of cow or sheep and it is endowed with a proportionate appetite (10). The paucity of available information on glucose tolerance of goats prompted this study. The investigation was conducted on the dwarf (short-legged) goats of West Africa, a breed that has attracted scant attention from physiologists.

MATERIALS AND METHODS

West African dwarf goats, 3 females aged about 9-12 months, a one year buck and 3 kids (1 male and 1 female aged 41 days each, and 1 female aged 33 days), maintained in the University Farm, formed the experimental animals. All the animals were healthy and in good nutritional status The kids were on mothers milk and were also fed concentrates and leaves. They were consuming appreciable quantity of leaves. Adult ruminants need not be fasted before glucose tolerance tests (7). However, concentrates were withdrawn from the ration of adult goats and kids 24 hr before the experiment, but leaves were provided *ad libitum*. The kids were separated from their mothers 3 hr before the test.

Two separate experiments were conducted using the same animals. In experiment 1, the animals were weighed individually and then administered intravenously (i.v.) a 50% solution of glucose (7) at the rate of 1 *ml/kg* body weight, taking about 3-5 min for the injection. Blood samples were collected from the animals before (basal), immediately after ('0' time) and at 1 hr after administration of glucose. Thereafter, blood samples were collected at 30 min intervals up to 3 hr. All the blood samples were analysed for glucose.

The experiment 2 was conducted to evaluate half-time ($T\frac{1}{2}$) and other biokinetics of glucose clearance. This was carried out 1 month after the first experiment in the case of adult goats and 15 days in the case of kids The experiment was conducted in an exactly similar manner as before, except that the blood samples were collected before (basal) and immediately after ('0' time) i.v. administration of glucose and thereafter, at 15 in mintervals upto 1 hr.

Blood was collected from the jugular vein using sodium fluoride as anticoagulant (10 *mg/ml)* blood). The protein-free blood filtrate was prepared by the method of Somogyi Schaffer-Hartman (13) using zinc sulphate for precipitating proteins The filtrate by this method contains only glucose as reducing substance and hence, the estimates were the true glucose values. The filtrate was assayed for glucose by the method of Folin and Wu (13).

In the statistical analysis, Students t and Anova tests (14) were conducted. To determine the half-time ($T\frac{1}{2}$) semilogarithmic plots of the blood glucose at different time intervals after i.v. administration of glucose in adults and kids were made. The formulae for calculating the biokinetics were adopted from Mixner and Lennon (12).

RESULTS AND DISCUSSION

Table I gives the blood glucose of the adult goats and kids in experiment 1, just before (basal), immediately after ('0' time) and at different time intervals from 60 min to 180 min postglucose administration (PGA) i.v. (0.5 *g/kg* body weight).

The basal blood glucose in adult goats (54.36±1.36 *mg%*) in this study compare with that reported (45-60 *mg%*) for goats (7). The higher blood glucose in the kids (80.94±2.57 *mg%*) than in the adults ($P<0.01$) is expected as young ruminants and adult non-ruminants have similar blood glucose levels (1).

TABLE I : Glucose tolerance in kids and adult goats in experiment 1.

Goat/Sex	*Blood glucose (mg%)*						
	Basal	*Minutes after glucose injection*					
		0'time	60	90	120	150	180
Kid/M	77.81	273.63	73.95	70.83	75.52	68.61	84.86
Kid/F	78.85	236.46	64.87	79.17	75.52	72.92	71.11
Kid/F	86.15	210.07	71.24	76.92	69.40	85.13	76.77
Mean	80.94	240.05**	70.02*	75.64	73.48*	75.55	77.58
SEM	2.57	18.46	2.69	2.49	2.04	4.97	3.99
Adult/M	54.05	275.67	135.17	118.92	89.19	88.59	67.57
Adult/F	51.19	259.52	114.29	86.90	72.61	54.76	53.57
Adult/F	57.81	260.42	131.77	101.56	85.42	82.67	69.44
Adult/F	54.40	301.57	155.50	111.92	63.73	62.18	54.40
Mean	54.36	274.29**	134.17**	104.82**	77.73**	72.05*	61.24
SEM	1.36	9.81	4.67	6.98	5.90	8.08	4.24

*$P<0.05$ and **$P<0.01$ compared to basal level.

The increment in blood glucose immediately PGA was more or less to the same magnitude in adults (274.29±9.81 *mg%*) and kids (240.04±18.46 *mg%*). In adults. eventhough the blood glucose steadily decreased during the experimental period, hyperglycemia persisted at 150 min ($P<0.05$); the basal blood glucose was restored only 180 min PGA. In the kids, at 60 min PGA, the blood glucose (70.02±2.69 *mg%*) was below the basal level ($P<0.05$) Evidently, they were able to dispose off the excess load of glucose in a much shorter time than the adults. During the remaining period of study, the blood glucose in the kids showed a tendency to stabilize.

Fig. 1 is a semilogarithmic plot of blood glucose response to the test dose of glucose (0.5 *g/kg* body weight) in adult and kids in experiment 2. The faster rate at which the kids were able to clear the glucose increment PGA compared to adults is demonstrated by the steeper slope of the graph for kids. In this experiment, at 45 min, PGA, the blood glucose in kids (73.79$\pm$6.19 *mg*%) returned to the basal level (75.82$\pm$1.93 *mg*%). At 60 min PGA they exhibited hypoglycemia (58.98$\pm$3,05 *mg*%, $P<0.01$ compared to basal level).

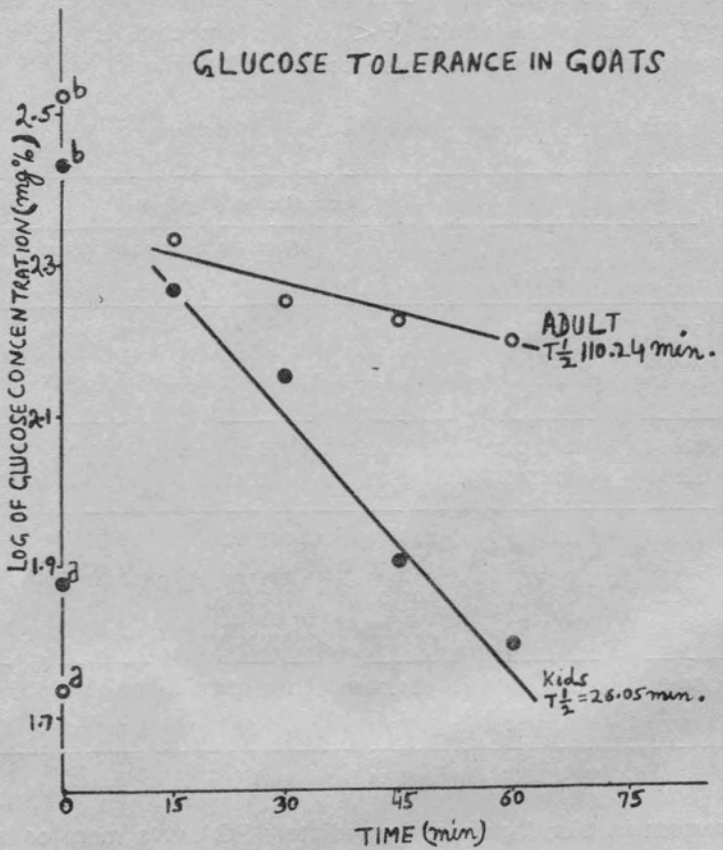

Fig. 1 : Semilogarithmic plot of the blood glucose response to a test dose of glucose in kids and adult goats during the first hr after intravenous injection.

a : Basal glucose.

b : 'O' time glucose.

Each point represents the group mean

In non-ruminants like the dog, the time taken for blood glucose to return to normal, PGA is only 60-90 min (7). The much longer duration (180 min) required for this by the adult goats as well as the substantial difference in the glucose clearance time between the adults (180 min) and kids (45 min), in this study, agree with the observation of others (6,11) in similar studies in sheep that injected glucose is removed from the blood stream in the adults at a much slower rate than in non-ruminants or in very young lambs.

Table II presents the data for glucose biokinetics for the goats in this study. The kids exhibited a higher turnover rate (K), and a much shorter turnover time (T_T) and $T\frac{1}{2}$ compared to the adults ($P<0.01$) in all cases. This taken along with their ability to restore basal glucose level within 45 min PGA compared to the 180 min for this in the adults and the hypoglycemia that follows at 60 min PGA suggest a more efficient insulin response to hyperglycemia in the kids. Jarrett *et al.* (6) using isotope dilution technique found that young lambs have a much higher glucose utilization than the adults.

TABLE II : Biokinetics of glucose tolerance in kids and adult goats in experiment 2.

Chracteristics	*Kids*	*Adults*
Number of animals	3	4
Body weight, *kg*	2.67 ± 0.17[a]	12.00 ± 1.47
Basal glucose, *mg%*	75.82 ± 1.93	55.26 ± 2.90**
Turnover rate, K, per hr	1.59 ± 0.12	0.38 ± 0.03**
Turnover time, T_T, hr	0.64 ± 0.04	2.64 ± 0.18**
Half-time, $T\frac{1}{2}$, min	26.05 ± 4.36	110.24 ± 7.73**

[a] Mean $\pm$ SEM
**$P<0.01$ compared to kids.

Kaneko and Rhode (8) in glucose tolerance studies conducted on normal cows got a turnover rate (K) of 1.39-1.02/hr, turnover time (T_T) of 0.72-0.98 hr and $T\frac{1}{2}$ of 0.50-0.68 hr. The adult goats in this study exhibited a much lower K (0.38 ± 0.03/hr), and very high T_T (2.64 ± 0.18 hr) and $T\frac{1}{2}$ (110.24 ± 7.73 min). Presumably, goats and cows, though ruminants, exhibit outstanding differences in their homeostatic responses to induced hyperglycemia. The high roughage and low concentrate content of the ration of the experimental goats might have contributed, to some measure, to the low glucose tolerance of these animals. Hale and King (3) demonstrated that grain fed lambs had much higher glucose tolerance than hay fed lambs.

ACKNOWLEDGEMENTS

Senate Research Grant No. 00241/76 awarded for the investigation by the University of Nigeria, Nsukka and the valuable help in the preparation of the manuscript by Dr. T. N. Kamalu, Department of Veterinary Physiology and Pharmacology are gratefully acknowledged.

REFERENCES

1. Allen, R.S. Carbohydrate metabolism. In Dukes Physiology of Domestic Animals, 9th edn. Ed. M.J. Swenson. Cornell University Press, Ithaca, pp. 327-335, 1977.

2. Edwards, A.V. Carbohydrate metabolism in young animals. In Physiology of Digestion and Metabolism in the Ruminant. Proceedings of the Third International Symposium Ed. A.T. Phillipson. Oriel Press Ltd., Newcastle upon Tyne, pp. 180-198, 1969.

3. Hab, W.M. and RP. King. Glucose tolerance in lambs as affected by the type of ration. *Proceedings of the Iowa Academy of Science,* **65** : 224-229, 1958.

4. Holmes, J.R. Carbohydrate metabolism in the bovine. I. Intravenous glucose tolerance in the healthy cow. *J. Comp. Path. Ther.,* **61** : 1-14, 1951.

5. Jarrett I.G. and B.J. Potter. Carbohydrate metabolism in the young lamb. *Aust. J. Exp. Biol. Med. Sci.,* **30**: 207-212, 1952.

6. Jarrett, I.G., G.B. Jones and B.J. Potter. Changes in glucose utilization during development of the lamb. *Biochem. J.,* **90** : 189-194, 1964.

7. Kaneko, J.J. Carbohydrate metabolism. In Clinical Biochemistry of Domestic Animals, vol. I. 2nd edn. Eds. J.J. Kaneko and C.E. Cornelius. Academic Press, New York, pp. 1-52, 1970.

8. Kaneko, J.J. and E.A. Rhode. Diabetes mellitus in a cow. *J. Amer Vet. Med. Assoc.,* **144** : 367-373, 1964.

9. Leng, RA. Glucose synthesis in ruminants. In Advances in Veterinary Science and Comparative Medicine. Eds. C.A. Brandly and C.E. Cornelius, vol. 14. Academic Press, New York, pp. 209-260, 1970.

10. Mackenzie, D. The principles of goat feeding, Goat Husbandry, 3rd edn., Faber and Faber Ltd. London, pp. 137-169, 242-267, 1970.

11. McCandless, E.L. and J.A. Dye. Physiological changes in intermediary metabolism of various species of ruminants incident to functional development of rumen. *Amer. J. Physiol.,* **162** : 434-446, 1950.

12. Mixner, J.P. and H.D. Lennon. Thyroxine secretion rates in dairy cattle as calculated from plasma levels, turnover rate, and volume of distribution of thyroxine. *Proceedings of the XV International Dairy Congress,* **1** : 20-26, 1959.

13. Oser, B.L. Hawk's Physiological Chemistry, 14th edn. The Blakiston Division, McGraw-Hill Book Company, New York, pp. 975-1152, 1965.

14. Phillips, D.S. Basic Statistics for Heath Science Students. W.H. Freeman and Company, San Fransisco, pp. 76-86, 93-108, 1978.

15. Reid, R.L. Studies on the carbohydrate metabolism of the sheep. V. The effect of hyperglycemia and of insulin on the rate of exptrahepatic glucose assimilation. *Aust. J. Agri. Res.,* **3** : 160-167, 1952.