Glucose Tolerance in a Saharan Nomad Population —the Broayas, from the Toubou Ethnic Group

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SUMMARY

Oral glucose tolerance was studied in the Toubou Broayas living in northeastern Niger. Mean fasting plasma level of glucose was 64 ± 22 (S.D.) mg./100 ml. Two hours after oral administration of 100 gm. glucose, the level was 74 ± 26 mg./100 ml. Plasma insulin levels were, respectively, 18 ± 13 and 36 ± 24 μU./ml. There was no sex difference. Older subjects had higher glucose levels and heavier females had higher insulin levels two hours after glucose administration. In six subjects (4 per cent) the plasma glucose level exceeded either 110 or 130 mg./100 ml. in the fasting state or after glucose administration, respectively, without, however, exceeding 150 mg./100 ml. in any of them. The low prevalence of glucose intolerance in this population is discussed with regard to their nutritional conditions (80 per cent carbohydrates) and their physical activity (nomadism).

The Broaya group, in whom obesity is unknown, appears to be well adapted to its extreme environment. DIABETES *24*:983-87, November, 1975.

The Toubou ethnic group is confined in a large Saharan area, including the northern part of Chad, the southern part of Libya, and the eastern part of Niger. The Toubous have Europoïd features and straight hair, although they have a dark complexion. Their physical resistance is outstanding.[1] Their racial homogeneity and nomad way of life have remained unchanged for centuries.[1,2] Consequently, they are very well adapted to a traditional way of living in an "extreme" environment, characterized by dryness and limited food availability.

The Broaya group, inhabiting northeast Niger, was studied in November-December 1971 by the Belgian Anthropologic Mission in Niger. At this period of time, their food consisted of millet seeds, fresh or desiccated dates, and doum nuts. Food intake amounted to approximately 400 to 450 gm. carbohydrates (about 5 per cent as refined sugar), 15 to 20 gm. lipids, and 40 to 45 gm. proteins. Caloric intake was about 2,000 kcal. per day. This community, composed of about 800 individuals, live in small groups of one to four families (about five to twenty members). These small groups were located by plane and asked to gather together in central spots, where some fifty people could be subjected to test. When necessary, trucks were used to convey communities situated too far away. Carbohydrate tolerance was studied in almost all Broaya subjects aged above seventeen years who could be located and contacted. Because of the dispersed locations, some groups of families were overlooked; however, it can be estimated that 50 to 60 per cent of all subjects older than seventeen years were tested.

METHODS

One hundred and five females (157 ± 6.5 cm. and 46.1 ± 5.6 kg.) and fifty-six males (163 ± 10 cm. and 49.9 ± 8.8 kg.) were included in the study.

One hundred grams of glucose was given orally in the morning to all subjects, who were asked to remain fasting from the evening before the test.

Blood was drawn before and two hours after glucose administration and was centrifuged immediately.

After addition of sodium azide, plasma was kept frozen at -20° C. until analyzed for glucose[3] and insulin content.[4]

RESULTS

Table 1 shows the distribution of the whole popula-

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TABLE 1

Distribution of subjects

Number of cases at		Plasma glucose levels (mg./100 ml.)								
		15-30	31-45	46-60	61-75	76-90	91-105	106-120	121-135	136-150
0 hr.	M - F*	3-2	8-15	14-40	14-19	4-23	6-0	2-1	1-1	0-2
	Total	5	23	54	33	27	6	3	2	2
2 hr.	M - F	0-2	6-7	11-20	10-22	10-24	3-9	5-6	1-2	1-3
	Total	2	13	31	32	34	12	11	3	4
		Insulinemias (μU./ml.)								
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	> 80
0 hr.	M - F	15-27	19-50	13-12	0-3	3-4	2-3	0-0	0-1	0-1
	Total	42	69	25	3	7	5	0	1	1
2 hr.	M - F	4-5	9-23	14-18	3-20	5-10	7-4	2-5	1-3	1-6
	Total	9	32	32	23	15	11	7	4	7
		I/G (μU./ml.) / mg./100 ml.								
		0-0.10	0.11-0.20	0.21-0.30	0.31-0.40	0.41-0.50	0.51-0.60	0.61-0.70	0.71-0.90	> 0.91
0 hr.	M - F	2-5	21-36	12-29	4-13	6-8	3-1	2-3	2-2	0-4
	Total	7	57	41	17	14	4	5	4	4
2 hr.	M - F	2-1	7-7	6-22	4-14	7-13	6-10	5-12	2-8	6-8
	Total	3	14	28	18	20	16	17	10	14

*M = males; F = females

TABLE 2

Mean values and standard deviations (S.D.) of the whole group

Total	Plasma Glucose (mg./100 ml.)		Insulinemia (μU./ml.)		I/G	
	0 hr.	2 hr.	0 hr.	2 hr.	0 hr.	2 hr.
Median	60	72	14	29	0.24	0.42
Mean ± S.D.	64 ± 22	74 ± 26	18 ± 13	36 ± 24	0.30 ± 0.22	0.53 ± 0.41
n*	155	142	153	140	153	140
Males						
Median	61	69	14	27	0.23	0.43
Mean ± S.D.	65 ± 23	74 ± 26	18 ± 12	35 ± 23	0.30 ± 0.19	0.53 ± 0.39
n	52	47	52	46	52	45
Females						
Median	60	72	13	31	0.24	0.42
Mean ± S.D.	63 ± 20	75 ± 25	18 ± 14	37 ± 24	0.31 ± 0.24	0.53 ± 0.41
n	103	95	101	94	101	95

*n = number of subjects.

tion on the criteria of plasma glucose and insulin levels, before (0 hr.) and two hours after glucose administration.

Table 2 gives the mean values of these parameters and the I/G ratios. There was no statistically significant difference between the sexes. These data were analyzed in relation to age and weight in ninety-five subjects (twenty-seven males and sixty-eight females) whose age could be recorded with a reasonable degree of certainty. Table 3 shows the age distribution in this reduced group. Table 4 gives the weight distribution, expressed as per cent of the ideal weight for age, sex,

TABLE 3

Age Distribution (Number of subjects and %)

Age range	Males	Females	Total
17 - 25	7 (26)	25 (37)	32 (34)
26 - 35	7 (26)	16 (24)	23 (24)
36 - 45	2 (7)	11 (16)	13 (14)
46 -55	6 (22)	7 (10)	13 (14)
older than 56	5 (18)	9 (13)	14 (15)
Total	27 (100)	68 (100)	95 (100)

and height. This "ideal weight" was taken from the Society of Actuaries (U.S.A.),[5] and must be considered only as a reference scale to analyze the weights relative to those found in Western industrialized countries. The mean "ideal weight" was close to 80 per cent in both sexes. Only four women (6 per cent) exceeded slightly the 100 per cent ideal weight.

Table 5 shows that plasma glucose levels two hours after glucose administration were significantly higher in the older group (more than forty-five years) than in the younger group. Fasting levels had a tendency to be higher in the older groups, but the differences were not significant. Insulin levels were not different in any of the groups.

Table 6 shows the effect of weight in the females divided into two weight groups: less than 90 per cent and above 90 per cent of "ideal weight." Males were not included in this study as only two of them exceeded 90 per cent of ideal weight. Females with higher relative weight had a significantly higher insulin response at two hours to the glucose challenge.

Twenty-eight subjects (eleven males and seventeen females) had fasting plasma glucose levels below 46 mg./100 ml. (table 1). Table 7 shows the four parameters calculated separately for this group of hypoglycemic subjects. Plasma glucose levels at two hours were significantly lower than the corresponding values for the whole population (table 2). It should be noted, however, that twelve of the nineteen of these whose age was known were younger than twenty-five years. Their weights were "normal" (82.3 ± 8.0 per cent of "ideal" weight).

TABLE 5

Effect of age on plasma glucose (G : mg./100 ml.) and insulin (I : μU./ml.) levels (mean ± S.D.)

		0 hr.		2 hr.	
Age (years)		G	I	G	I
Males	<45	57 ± 23 (16)	16 ± 12 (16)	66 ± 23† (15)	26 ± 14 (15)
	>45	75 ± 28 (10)	15 ± 7 (10)	92 ± 30† (10)	29 ± 16 (9)
Females	<45	61 ± 23 (52)	18 ± 14 (52)	74 ± 26* (49)	38 ± 26 (49)
	>45	69 ± 16 (15)	15 ± 10 (14)	92 ± 27* (16)	29 ± 19 (n = 16)

* : $p < 0.025$; † : $p < 0.005$; (n) = number of subjects.

On the basis of 110 mg./100 ml. at 0 hour and 130 mg./100 ml. at two hours as arbitrary upper normal limits for plasma glucose levels, seven subjects were found to be above these bounds. Their data are detailed in table 8. The weights were close to the mean of the whole group. All except one of these subjects had I/G ratios below the mean at 0 hour. Two of four had low I/G ratios at two hours. Subject no. 7 had a high I/G ratio at 0 hour together with a high blood glucose level. This suggests that the subject was not in a fasting state, as it should have been at 0 hr. Subject no. 6 had the next highest glucose level at 0 hours and a low I/G ratio, suggesting inappropriate insulin secretion. Unfortunately, the values at two hours were not available in these subjects. Thus, the proportion of "abnormal" glucose tolerance did not exceed 4 per cent of the whole group. The diabetic tendency in these few subjects should, however, be considered as borderline, taking into account their age (half of them above forty-five years), the rather large glucose load (100 gm.), and the fact that plasma and not whole-blood values were determined.

DISCUSSION

The Broaya group was characterized by a somewhat

TABLE 4

Weight distribution (number of subjects and %)

% "Ideal" weight	Males	Females	Total
61 - 70	3 (11)	10 (15)	13 (14)
71 - 80	13 (48)	20 (29)	33 (35)
81 - 90	9 (33)	23 (34)	32 (34)
91 - 100	2 (7)	11 (16)	13 (14)
100 - 110	0	4 (6)	4 (4)
Total	27 (100)	68 (100)	95 (100)
Mean ±S.D.	78.3 ± 7.8	83.2 ± 11.4	81.2 ± 10.6

TABLE 6

Effect of weight on plasma glucose (G : mg./100 ml.) and insulin (I : μU./ml.) levels in women (mean ± S.D.)

% "ideal" Weight	0 hr.		2 hr.	
	G	I	G	I
<90	63 ± 23 (52)	18 ± 13 (51)	77 ± 26 (51)	31 ± 21* (51)
>90	60 ± 19 (15)	16 ± 13 (15)	83 ± 29 (14)	52 ± 31* (14)

* : $p < 0.01$; (n) = number of subjects.

TABLE 7

Plasma glucose (G : mg./100 ml.) and insulin (I : μU./ml.) in subjects with fasting glucose level below 46 mg./100 ml.

	G	I
0 hr.	38 ± 7 (28)	15 ± 9 (28)
2 hr.	57 ± 20* (25)	31 ± 14 (25)

* $p<0.005$ as compared to the whole population.

lower fasting glycemia than western European populations.[6] Fasting insulinemia levels were similar to those reported for western European countries.[7] The well-known effect of age on reducing glucose clearance[8] was also observed in this population.

One third of the younger subjects aged seventeen to twenty-five years had fasting glycemia lower than 46 mg./100 ml. In these young subjects glycemia remained low two hours after glucose ingestion, although their insulin levels were normal. The high insulin sensitivity of these subjects was not related to reduced weight; the latter was normal as compared with the whole group. Some degree of insulin resistance could eventually be observed in the heaviest females (91 to 110 per cent ideal weight). Their insulin response to the glucose load was indeed significantly higher than that of the lighter women, although plasma glucose levels were the same. This situation parallels the relative hyperinsulinemia described in obese subjects.[9] It should be remembered, however, that the heaviest Broaya females did not exceed 110 per cent of "ideal" weight and were not obese. (They did not, furthermore, look fat.)

Glucose tolerance appeared to be normal in more than 95 per cent of the population, which is better than what has been observed in western European populations, in whom the prevalence of diabetic response is higher.[10]

TABLE 8

Plasma glucose (G : mg./100 ml.) and insulin (I : μU./ml.) levels, and I/G Ratios in "Abnormal" Subjects

Subject No.	Sex	Age	% Ideal weight	0 hr. G	0 hr. I	0 hr. I/G	2 hr. G	2 hr. I	2 hr. I/G
1	F	60	74.0	68	6	0.09	136	24	0.18
2	F	40	79.4	70	10	0.14	138	84	0.61
3	F	70	76.3	86	21	0.23	149	66	0.44
4	F	28	85.0	124	32	0.26	—	—	—
5	M	50	75.5	125	25	0.20	143	23	0.16
6	F	—	—	139	15	0.11	—	—	—
7	F	35	76.3	146	72	0.50	—	—	—

The glucose homeostasis of the Broayas is then similar to that of the Bantus,[11,12] the Eskimos,[13] the Athabascan Indians of Alaska,[14] and some other Indian tribes of North America.[15] It differs from the high diabetic prevalence of the Pima Indians,[16,17] the Cocopah,[18] the Cherokee,[19] and the Seneca[20] of North America, and of Indian groups of Asiatic origin in Cape Town.[12]

Although racial peculiarities may play a role in these differences,[15,21] environmental factors appear to exert a great influence on glucose tolerance.[15] For instance, the Athabascan Indians, although living in the same environment as the Eskimos, are racially closer to the Pima Indians, yet their glucose tolerance is closer to that of the Eskimos and differs considerably from that of the Pima Indians.

The Broayas differ racially from both the Eskimos and the North American Indians. Their nutritional conditions, consisting of a high proportion of carbohydrates in their sources of energy, are closer to those of the Pima Indians. The Bantus also consume a large amount of carbohydrate in their usual diet. However, the Broayas and the Bantus[11,12] have few cases of glucose intolerance, whereas the Pima Indians[16,17] have many cases. Yet the amount of unrefined carbohydrates in the diet[22] is not as such involved in the elicitation of glucose intolerance. Physical exercise is a characteristic that the Broayas, being seminomadic, share with the Eskimos,[13,22] whereas the Pima Indians have been confined to a sedentary way of life.[16,17] Hence Broayas are lean and Pima Indians are obese.[16,17] Obesity has indeed been correlated with the prevalence of diabetes.[22]

This study of the small and well-defined Broaya group, which has conserved its racial homogeneity as well as its traditional way of life for centuries, emphasizes the importance of the long-term adaptation of people living in an extreme and rather confined environment. Changing such an environment, as the Pima Indians did by becoming sedentary, carbohydrate-eating, and obese, may be an excessive challenge and lead to a new, unadapted metabolic situation.

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