

Sucrose and Delinquency: Oral Sucrose Tolerance Test and Nutritional Assessment

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ABSTRACT. Claims that juvenile delinquency may be associated with reactive hypoglycemia or nutritional deficiencies have received widespread attention but little objective evaluation. To assess the validity of these claims, nutritional and psychological indices of juvenile delinquents have been measured. Serum glucose and insulin profiles during an oral sucrose tolerance test were measured in 137 delinquent and 41 nondelinquent male adolescents aged 14 to 19. In addition, nutritional status of both populations was assessed by anthropometry (height, weight, arm circumference, triceps skin fold) and biochemical measures (hematocrit, red-blood cell thiamin, and serum copper, ferritin, and zinc). Delinquent subjects had slightly but significantly lower serum glucose values at four of six time points (fasting, 60 minutes, 120 minutes, 180 minutes) and higher serum insulin values at one time point (30 minutes) compared with nondelinquent subjects. Changes in glucose from fasting levels indicate that these subjects were regulating serum glucose adequately, but doing so at lower values; changes in insulin from fasting levels indicate that black delinquents initially secreted more insulin than either white subject group. There were no significant associations between excursions in serum glucose or insulin and any adrenergic signs or symptoms of low blood glucose levels. Nutritional status of incarcerated delinquents did not differ from that of nonincarcerated subjects on most measures. Although the significantly lower serum glucose levels and higher serum insulin levels are intriguing, no support is offered by results of this study for allegations that sucrose ingestion causes reactive hypoglycemia in juvenile delinquents or that delinquent male adolescents are at greater risk nutritionally than male adolescents of the same age who are not delinquent. Results of the psychological studies

described in the accompanying article in this issue support this conclusion. *Pediatrics* 1990; 86:254-262; *male adolescent, behavior, hypoglycemia, nutrition, oral sucrose tolerance test.*

Claims that juvenile delinquent behavior may be associated with consumption of sucrose have received widespread attention (*The New York Times*, December 4, 1984; 21, 24).¹⁻⁸ Reactive hypoglycemia,³ sensitivity to sugar,⁴ vitamin/mineral deficiencies due to metabolism of excessive dietary sugar,⁵ and neurotransmitter abnormalities⁶ have all been proposed as possible physiological conditions contributing to aggressive, antisocial behavior. Although these assumed relationships are based largely on subjective and anecdotal reports and misinterpretation of the scientific literature,² some juvenile detention and correctional facilities have changed institutional diets by eliminating or reducing sugar in the belief that such modifications can prevent or correct undesirable behaviors.⁷

Assumptions underlying such public policy decisions far exceed scientific knowledge. To date, no credible research exists relating antisocial adolescent behavior to sucrose consumption; studies thus far done within the correctional setting⁸ have serious methodological and interpretative flaws.⁷ However, studies done on both the etiology of childhood hyperactivity and variations in carbohydrate metabolism of adult criminals may offer useful clues for analyzing possible links between sucrose ingestion and delinquency. Food dyes and naturally occurring salicylates have little effect on childhood hyperactivity⁹⁻¹¹; but the diets of some of the hyperactive children studied were high not only in dyes and salicylates but also in refined sugars.

Received for publication Mar 15, 1989; accepted Aug 3, 1990.
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Thus, it has been proposed that any improvement in behavior could have been due to the inadvertent elimination of sugar.¹² Most recent studies do not support a sugar-behavior link,^{13,14} but agreement is not unanimous.^{15,16} Results of research on adult offenders habitually violent under the influence of alcohol has uncovered several metabolic anomalies that could be indicative of impairment of intermediary metabolism: unusual glucose¹⁷ and insulin¹⁸ responses during an oral glucose tolerance test, low cholesterol levels,¹⁹ and changes in plasma amino acid levels.²⁰

This article is the initial report of results from an interdisciplinary study designed to provide an objective evaluation of possible associations between sucrose ingestion and juvenile delinquent behavior. The objectives were to characterize juvenile delinquent subjects in terms of both nutritional and psychological indices, to categorize the subjects in terms of their physiological responses to sucrose, and to describe how subjects differ in performance following ingestion of sucrose or a placebo. In this first article, we deal with specific aspects of nutritional and metabolic assessment of the total sample of subjects: glucose and insulin responses to an oral sucrose tolerance test (OSTT), concomitant subjective mood measurements, and selected indices of nutritional status. In the article that follows,²¹ we describe and discuss behavioral results from a subset of subjects in this paper.

METHODS

Subjects

The delinquent subject group was comprised of 137 male adolescents confined to Ethan Allen School, Wales, WI, a maximum security state correctional facility. The nondelinquent group was 41 male adolescents concurrently attending high schools in the Madison Metropolitan School District, Madison, WI. The delinquent group was racially diverse: 63 black, 63 white, 5 hispanic, 2 native Americans, and 4 racially mixed; the nondelinquent group consisted of white students only. We chose to limit the comparison group to white subjects for two reasons related to the psychological data set. First, to retain statistical power for planned analyses involving subgroups and remain within the project budget, it was necessary to target either a white or a black comparison group but not both. Second, since norms for many psychological measures are race- and culture-dependent, we questioned the legitimacy of using local black students as a comparison group for the incarcerated black subjects who were for the most part from inner city neighborhoods of large cities. Thus, we describe

and discuss nutritional data from three groups of subjects: black delinquents, white delinquents, and white nondelinquents.

All delinquents at the correctional institution were offered the opportunity to participate; then selection from the group of delinquents who volunteered was random, but limited to those residents who were 14 to 19 years of age. Selection of the nondelinquent group was from a volunteer pool of high school students who had no juvenile record and who were matched to the white delinquent group as closely as possible with regard to IQ or socioeconomic status; see Bachorowski et al,²¹ for a more complete discussion of subject selection. Average age of both groups was about 16.7 years. Written permission was subsequently obtained from all subjects and parents of those subjects younger than 18 years of age. The school health records of each subject were checked by a health professional for contraindications to participation and current drug therapy was noted. At the time of the study, 160 subjects were using no medically prescribed or over the counter drugs; no nutritional data from the remaining 19 subjects were omitted because of currently prescribed medication.

All aspects of the study were approved by the Human Subjects Committee, University of Wisconsin Hospital, Madison; the Research Review Committee, Division of Corrections, Department of Health and Social Services, State of Wisconsin; and the External Research Committee, Madison Metropolitan School District.

Study Design

On the morning of the OSTT, subjects arrived at the testing site (on the grounds of the correctional facility or the Nutritional Sciences Department, University of Wisconsin-Madison) at 6:30 AM. Subjects were asked to refrain from eating or drinking anything but water after 9 PM the previous evening; no other restrictions were placed on the subjects' diets.

Anthropometric measurements (height, weight, arm circumference, triceps skin fold) were taken and several mood questionnaires administered as soon as the subjects arrived. Subjective estimates of mood included the Profile of Mood States, a 65-item adjective rating scale, with a "right now" rating period²²; the Stanford Sleep Scale, a 7-item self-rating scale used to quantify sleepiness²³; and the Carbohydrate Tolerance Questionnaire, an instrument designed for the study. The Carbohydrate Tolerance Questionnaire contained 3 observer-rated evaluations and 5 Visual Analogue Mood Scale²⁴ self-evaluations of mood states or physical

feelings commonly associated with the adrenergic symptoms of low blood glucose. An indwelling venous catheter was then installed in each subject's arm or hand vein and the fasting blood sample (15 mL total) was drawn. Each adolescent drank 250 mL of a 0.88-mol/L (75 g) unflavored sucrose solution within approximately 5 minutes. Five subsequent blood samples of 4 mL each were drawn at 30, 60, 120, 180 and 270 minutes after the fasting sample. The Profile of Mood States was administered again at 60 minutes and 180 minutes; the Stanford Sleep Scale and Carbohydrate Tolerance Questionnaire were administered immediately before each blood sampling. Dietary intake information for the 3 days previous to the OSTT was collected. After completing the protocol, subjects were provided with lunch and returned to their respective schools or homes.

Analytical Methods

Blood samples for hematocrit and serum glucose were processed the day they were taken; samples for red blood cell thiamin, and serum insulin, ferritin, zinc, and copper were stored in a frozen state for subsequent analyses.

Serum copper and zinc concentrations were measured by atomic absorption spectrophotometry (Perkin-Elmer model #372, Norwalk, CT) according to conventional methods.²⁵ Response of red blood cell transketolase after addition of thiamin pyrophosphate was determined by the method of Brin.²⁶ Serum glucose was determined using a glucose oxidase-peroxidase kit (Sigma Chemical Co/Sigma Diagnostics, St Louis, MO); serum insulin and serum ferritin were determined using radioimmune assays (Cambridge Medical Diagnostics, Billerica, MA; Ciba-Corning Diagnostics Corp, Medfield, MA).

Three-Day Dietary Intake

All delinquent subjects were taught how to keep a diet record. Almost all delinquent subjects ($n = 131$) completed 3-day diet records for the 3 days previous to the OSTT. Three-day recalls were collected from those 6 delinquent subjects who did not complete their records. Because of unreliable accessibility of nondelinquent subjects prior to the OSTT, 3-day diet intake information was collected from them ($n = 41$) by recall on the OSTT day. Two sample groups were selected for preliminary analyses of 3-day diet information: Group A consisted of information from all subjects ($n = 40$; 37 delinquents and 3 nondelinquents) who had nonfasting serum glucose values of <2.8 mmol/L (50 mg/dL) and group B consisted of all subjects ($n =$

68; 44 delinquents and 24 nondelinquents) who had nonfasting serum glucose values of >3.3 mmol/L (60 mg/dL). We analyzed 3-day diet information using Nutritionist III (N-Squared Computing, Silverton, OR).

Statistical Tests

Data are expressed as means \pm standard errors of the mean. Means of two groups were compared by two-tailed Student's *t* tests for unpaired data.²⁷ Means of three groups were compared by one-way analysis of variance;²⁸ subsequent planned comparisons of two groups were made by Bonferroni *t* tests.²⁸ Differences in mood data among or between groups were evaluated by either χ^2 ²⁷ or Student's *t* tests. Experiment-wise level of significance was $\alpha < .05$ for all statistical tests.

RESULTS

Anthropometric Measures

Characteristics of the three subject groups are shown in Table 1. Differences among the three groups in height, weight, height percentile, weight percentile, arm circumference, and triceps skin fold measurements were not statistically significant.

Biochemical Measures

There were no significant differences among the three groups on four measures of nutritional status, as shown in Table 2. Red blood cell transketolase response following the addition of thiamin pyrophosphate, an indirect measure of thiamin status, did not differ significantly among groups. Iron status, as measured by hematocrit and serum ferritin levels, did not differ among groups. Serum zinc levels did not differ significantly among the groups; serum copper levels were significantly higher in the black group as compared with either white group.

Three Day-Dietary Intake

Evaluation of intake information collected from the 40 group A subjects and the 68 group B subjects showed that of the total 108 subjects, 4 (4%) had an average carbohydrate intake of less than 150 g/d, 38 (35%) consumed 150 to 299 g/d of carbohydrate, and 66 (61%) consumed 300 g/d of carbohydrate or more. The average nutrient intakes of these two subsamples did not differ significantly on several measures (Table 3). Average consumption for both groups was at or near 100% of the age-specific Recommended Dietary Allowance for energy, which included an average of approximately 340 g/d of carbohydrate. Diets in all groups were self-selected.

TABLE 1. Anthropometric Measures for Black Delinquents, White Delinquents, and White Nondelinquents*

Anthropometric Measures	Black Delinquents (n = 63)	White Delinquents (n = 63)	White Nondelinquents (n = 41)
Height (cm)	174.4 ± 0.9	173.5 ± 0.8	175.4 ± 1.3
Wt (kg)	71.0 ± 1.4	67.7 ± 1.4	67.1 ± 2.1
Height percentile†	51.3 ± 2.1	46.8 ± 3.5	58.6 ± 3.3
Wt percentile†	65.6 ± 3.0	56.5 ± 3.3	56.5 ± 4.4
Arm circumference (cm)	30.6 ± 0.4	29.8 ± 0.3	29.0 ± 0.6
Triceps skin fold (mm)	11.7 ± 0.9	12.3 ± 0.7	11.9 ± 1.1

* Values are given as means ± standard errors of the mean.

† Based on National Center for Health Statistics physical growth charts (42).

TABLE 2. Vitamin and Mineral Status for Black Delinquents, White Delinquents, and White Nondelinquents*

Vitamin and Mineral Status	Black Delinquents (n = 63)	White Delinquents (n = 63)	White Nondelinquents (n = 41)
Thiamin pyrophosphate effect (%)	14.4 ± 5.3	12.6 ± 2.2	12.5 ± 2.1
Fractional hematocrit volume (%)	0.468 ± 0.003	0.477 ± 0.003	0.477 ± 0.004
Serum ferritin (μg/L)	52.9 ± 3.5	44.6 ± 3.1	44.5 ± 2.9
Serum copper (μmol/L)†	16.8 ± 0.4 ^c	15.0 ± 0.2 ^b	14.4 ± 0.2 ^b
Serum zinc (μmol/L)	15.6 ± 0.2	15.8 ± 0.2	15.7 ± 0.2

* Values are given as means ± standard errors of the mean.

† $P < .05$. Values with different superscripts differ significantly.

TABLE 3. Intake Data from Preliminary Analyses of Selected 3-Day Diet Records*

	Group A (n = 40)	Group B (n = 68)
Energy (% of recommended dietary allowance)	97 ± 5	100 ± 4
Carbohydrate (g)	332 ± 18	354 ± 15
% kcal†		
As carbohydrate	48 ± 1	50 ± 1
As protein	16 ± 1	15 ± 1
As fat	37 ± 1	35 ± 1

* Group A: subjects having nonfasting serum glucose nadirs <2.8 mmol/L (<50 mg/dL); Group B: subjects having nonfasting serum glucose nadir >3.3 mmol/L (>60 mg/dL). The differences between the two groups were not significant ($P < .05$). Values are given as means ± standard errors of the mean.

† Percentages may not add up to 100% because of rounding.

Glucose-Insulin Measures

Profiles of average serum glucose and insulin values for the three subject groups during the OSTT are shown in Figure 1. In all three groups, the time-course of both glucose and insulin responses and the average values at the individual times were consistent with values in the literature obtained using OSTT.^{29,30}

Subjects in at least one delinquent group had serum glucose levels (Fig 1, top) that were slightly but significantly lower than nondelinquent subjects at four of the six times of sampling: fasting, at 60 minutes, 120 minutes, and 180 minutes. In addition,

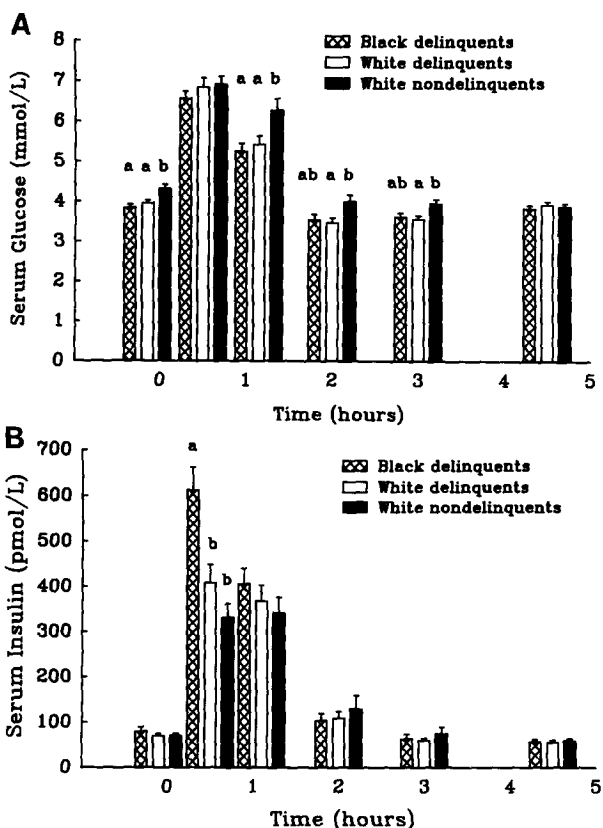


Fig 1. Metabolic responses during oral sucrose tolerance test (75 g of sucrose/250 mL of water) for black delinquents (n = 63), white delinquents (n = 63), and white nondelinquents (n = 41). Values are means ± standard errors of the mean; $P < .02$ for all comparisons. Bars with different superscripts differ significantly. Top, serum glucose; bottom, serum insulin.

at two of the same time points (fasting and at 60 minutes), both delinquent groups had serum glucose levels that were significantly lower than those of the nondelinquent subjects. Serum insulin levels (Fig 1, bottom) were significantly higher in the black delinquent group as compared with both delinquent and nondelinquent white subjects at 30 minutes only.

Significantly more (29%) of the delinquent group exhibited serum glucose levels of less than 2.8 mmol/L (50 mg/dL) at some time during the postprandial portion of the OSTT compared with the nondelinquent group (7%; $\chi^2 = 11.47, 2 df$).

Measurement of absolute serum glucose and insulin values across time presents one aspect of a group's response to an OSTT. Mean changes in metabolite levels relative to a common reference point such as fasting afford an alternative view of the data. Profiles of mean changes in both glucose and insulin levels from fasting levels during the OSTT for the three subject groups are shown in Figure 2. Changes from fasting serum glucose levels

did not differ significantly among groups between 30 and 180 minutes following the sucrose load; at the fifth time point, 270 minutes, the average time required for the black and white delinquent subjects to return to fasting glucose levels was slightly faster than that of the white nondelinquent subjects. Changes from fasting insulin levels differed significantly among subject groups at only the first time point; at 30 minutes the black delinquent subjects exhibited a higher insulin response than either group of white subjects.

Subjective Mood Measures

According to results of analysis of mood data collected from three instruments (Profile of Mood States, Stanford Sleep Scale, and Carbohydrate Tolerance Questionnaire), there were no significant associations between changes in mood or subjective physical feelings and excursions of either serum glucose or serum insulin across time after a sucrose load. Groups that exhibited low absolute glucose values (black delinquent and white delinquent subjects) and high absolute insulin values (black delinquent subjects) did not show signs and symptoms different from groups that exhibited more normal serum values. In particular, three sets (fasting, at 60 minutes, and at 180 minutes) of subscale data derived from the Profile of Mood States, a 65-item adjective checklist used extensively in psychological research,²² were treated as continuous variables. On five of the subscales (tension/anxiety, dejection/depression, anger/hostility, fatigue/inertia and confusion/bewilderment), both delinquent and nondelinquent subjects reported amelioration of mood as the OSTT morning progressed. On the sixth subscale (vigor/activity), subjects reported no difference in mood throughout time. On most subscales (depression/dejection, anger/hostility, confusion/bewilderment and fatigue/inertia), nondelinquent subjects reported more rapid improvement of mood across time.

A measure of sleepiness²³ was taken before each blood sampling; data were analyzed as discrete variables. After 2 hours into the OSTT, both delinquent and nondelinquent subjects reported feeling more awake than at zero hour. Scores on the Stanford Sleep Scale for delinquent subjects and for nondelinquent subjects were not significantly different at most time points during the OSTT. Similarly, scores of the three subgroups of subjects were not significantly different at most time points. When Stanford Sleep Scale scores were analyzed as continuous data, all subject groups reported being more awake with progression of time, and delinquent subjects' scores were not statistically different from

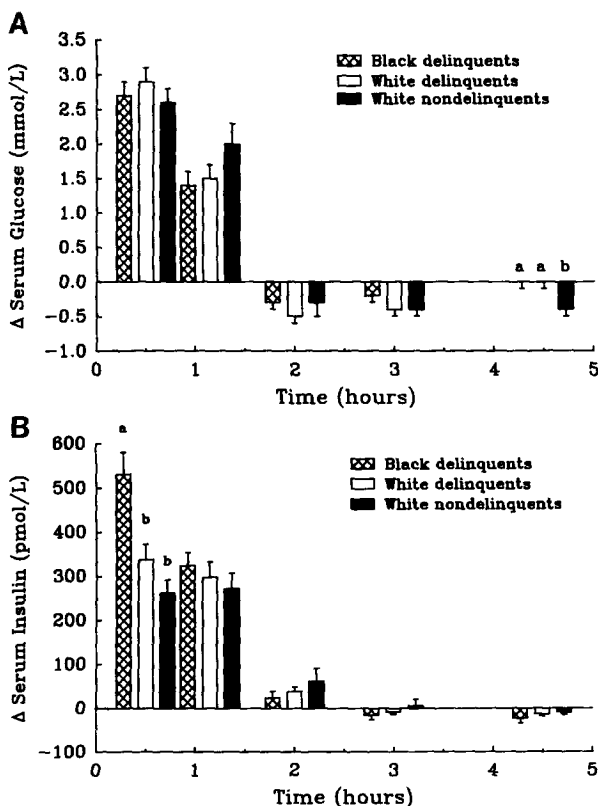


Fig 2. Changes from fasting value for metabolic responses during oral sucrose tolerance test (75 g of sucrose/250 mL of water) for black delinquents (n = 63), white delinquents (n = 63), and white nondelinquents (n = 41). Values are means \pm standard errors of the mean; $P < .02$ for all comparisons. Bars with different superscripts differ significantly. Top, serum glucose; bottom, serum insulin.

those of nondelinquent subjects at most time points. The results suggest that nondelinquent subjects were sleepier than delinquent subjects at the beginning of the morning, however.

Finally, two types of data from the Carbohydrate Tolerance Questionnaire were analyzed: one set as discrete data, the other set as continuous data. Discrete variables afforded measures of shakiness, acuity of eyesight, and pain or discomfort. On all three measures, there were no statistically significant differences between delinquent and nondelinquent subjects immediately before each of the six blood drawings. In addition, subjects reported no significant changes in visual acuity during the morning.

Analyses of continuous variables derived from five Visual Analogue Mood Scale-type items²⁴ provided further information about moods and symptoms related to changes in concentrations of serum glucose. Subject groups reported no significant differences during the OSTT with respect to sweaty vs dry or strong vs weak sensations. The adolescents, in general, were hungrier early in the morning, less hungry after ingesting the sucrose solution, and then more hungry as the morning progressed. Nondelinquent subjects reported no change during the OSTT on a tense to relaxed continuum; delinquent subjects reported feeling a shift from tense to relaxed as the morning progressed. Finally, both delinquent and nondelinquent subjects described a shift from feeling shaky to feeling calm during the 4½ hours of the OSTT.

In summary, there were no consistent patterns in physical symptoms or self-reported subjective mood states throughout the time of the OSTT among subject groups. Furthermore, there were no statistically significant linear correlations between moods or symptoms and serum glucose or serum insulin changes during the OSTT.

DISCUSSION

Reactive hypoglycemia, or sensitivity to sucrose, has been suggested in the public press (*The New York Times*, December 4, 1984; 21, 24; *San Francisco Chronicle*, September 30, 1982; 29), in non-peer-reviewed journals,^{31,32} and even before a US Senate Select Committee³³ as a possible correlate or cause of antisocial behavior. These suggested relationships are based on anecdote and misinterpretation. Nonetheless, public policy decisions such as changing diets in correctional facilities have already been instituted, based on these speculations.

To diagnose reactive hypoglycemia, three criteria must be met: (1) an episodic reduction of plasma or serum glucose to less than some critical value fol-

lowing ingestion of carbohydrate-containing food, (2) adrenergic symptoms accompanying the low blood glucose levels, and (3) alleviation of these symptoms within 10 to 15 minutes after ingestion of food.³⁴

Results of carbohydrate tolerance tests alone are difficult to interpret because of the frequency with which low glucose values can occur normally during the postprandial state. Rebound low blood glucose concentration is a normal physiological response to carbohydrate ingestion in general, or to sucrose or glucose ingestion in particular; and the minimum concentrations observed can be extremely variable in normal persons.³⁵ Virkkunen and Huttunen¹⁷ defined a low blood glucose level as one less than 2.6 mmol/L (47 mg/dL) in their studies of habitually violent adult male offenders. Sherwin and Felig³⁴ proposed using a cutoff of 2.8 mmol/L (50 mg/dL) for serum or plasma glucose. Blood glucose levels of as many as 42% of a normal asymptomatic subject population, however, have been recorded at less than 2.8 mmol/L (50 mg/dL) during a glucose tolerance test.^{36,37}

Although we observed statistically significant differences in serum glucose and insulin levels among delinquent and nondelinquent subject groups at various time points during the OSTT (Fig 1), we did not observe any associations between excursions of either serum glucose or serum insulin levels across time or any observed or reported adrenergic symptoms that accompany clinical reactive hypoglycemia. Thus, we conclude that there was no evidence of reactive hypoglycemia in any of our three subject groups.

The prevalence of low blood glucose levels, defined as a serum glucose level less than 2.8 mmol/L (50 mg/dL) did differ between delinquent and nondelinquent subject groups. Virkkunen³⁸ and Virkkunen and Huttunen¹⁷ made similar observations among diagnostic subgroups of adult male criminals who were habitually violent under the influence of alcohol, when compared with a group of psychiatric hospital personnel using a similar index (2.9 mmol/L for serum glucose, calculated value equivalent to 2.6 mmol/L blood glucose). We did not obtain measures of liver function, but liver damage from infection or alcohol and other drug use could allow serum insulin to persist because of lessened hepatic catabolism of insulin. If this occurred in some juvenile delinquents, their glucose levels could decrease to unusually low values during an OSTT.

It has been suggested that a high carbohydrate diet be eaten prior to the administration of a carbohydrate tolerance test to ensure adequate insulin secretion and, hence, reliable glucose responses. Several definitions of "high carbohydrate" have

appeared in the literature,^{30,39,40} one of the latest being 150 g/d.³⁹ Because the carbohydrate intakes of almost all group A and group B subjects were greater than 150 g/d and the average intake was approximately 340 g/d (Table 3), it seems unlikely that insulin secretion was inadequate. In addition, no significant association was detected between either energy or carbohydrate intake and low serum glucose values or high serum insulin values. Thus it may not be necessary to be concerned about some minimum level of carbohydrate intake prior to a carbohydrate tolerance test if energy intake is adequate.

Changes in glucose from fasting levels (Fig 2, top) indicate that, although absolute glucose values differed among groups, subjects exhibiting low serum glucose levels may be regulating serum glucose adequately but doing so at lower absolute levels. Differences among groups in changes in insulin values from fasting levels (Fig 2, bottom) as well as differences among groups in absolute insulin values (Fig 1, bottom) indicate that the black delinquent subjects secreted more insulin after a sucrose load than either white group. Because no adrenergic symptoms could be associated with serum glucose or serum insulin levels in any subject group, it seems unlikely that either the low serum glucose levels or the high serum insulin levels observed during the OSTT are necessarily indicative of any metabolic impairment—including clinical reactive hypoglycemia. Furthermore, we observed no statistically significant association between serum glucose and serum insulin levels; those subjects exhibiting low serum glucose levels were not necessarily the same subjects with high insulin production. Therefore, two separate mechanisms may have to be postulated to explain adequately the low glucose levels in both delinquent subject groups and the high insulin levels observed in the black delinquent subject group. This possibility requires further investigation. It is also interesting to note that performance on laboratory tasks that measure behaviors associated with aggression and impulsivity did not differ after a sucrose or no-sucrose breakfast in those adolescents who exhibited low serum glucose levels during the OSTT.²¹ Because mean performance measures were numerically higher after the sucrose breakfast, there is no basis for assuming that sucrose exacerbates delinquent behavior.

A variety of indices of nutritional status, both anthropometric and biochemical, were measured in delinquent and nondelinquent subjects to assess the scientific basis for speculations about links between incidence and severity of nutritional deficiencies and juvenile delinquency.^{3,5} We found no convincing evidence to support any such connection. Results of all of the selected anthropometric indices

(Table 1) were within normal ranges^{41,42} and there were no significant differences among subject groups.

Concentrations of selected vitamins and minerals in the blood (Table 2) did not differ significantly among groups for most nutrients. Using either Brin's indices⁴³ or the indices of the Interdepartmental Committee on Nutrition for National Defense⁴⁴ for thiamin status, we found about 78% of the total subject pool to have adequate thiamin levels. Other researchers⁴⁵ have reported "poor thiamin status" in male and female patients who consume a high percentage of their carbohydrate as refined, highly processed products, but no estimate of prevalence of thiamin deficiency in their total patient population was stated.

Detection of thiamin deficiency by Brin's methodology is dependent on response of the activity of transketolase, a thiamin pyrophosphate-requiring enzyme in human red blood cells, to addition of cofactor in the assay. If the transketolase apoenzyme is itself defective or deficient, as in alcoholism and in other disease states, interpretation of results from the assay becomes questionable.^{44,46} Although our data are suggestive that a portion of this population of male adolescents may be at risk for thiamin deficiency, in view of the failure to detect impaired glucose use during the sucrose tolerance test, further confirmatory measurements, such as urinary thiamin excretion, erythrocyte transketolase activity, or blood concentration of metabolically active thiamin compounds is warranted.

No differences among groups were significant on either measure of iron status. No subjects were at high risk for iron deficiency as measured by hematocrit: 6% of the total subject pool was marginally deficient when compared with age-specific criteria; 94% had levels above the minimum-for-age for acceptable iron status.⁴⁷ Iron stores were assessed by measuring serum ferritin; only 3% of the total subject pool had serum ferritin levels less than 12 $\mu\text{g/L}$, the value suggestive of depletion of stores.⁴⁸

Serum zinc concentrations did not differ significantly among groups and no adolescents had levels less than 10.7 $\mu\text{mol/L}$ (70 $\mu\text{g/dL}$), the suggested limit for adequate zinc levels.⁴⁹ Our finding that serum copper levels were significantly higher in the black subjects is similar to that previously reported in the Second National Health and Nutrition Examination Survey,⁵⁰ but average values for all three groups well exceeded levels thought to be indicative of deficiency. There is no currently accepted level that is used to define an adequate level for serum copper⁵¹; but only 2% of the total subject pool had levels less than the suggested 11.8 $\mu\text{mol/L}$ (75 $\mu\text{g/dL}$) (Greger JL, unpublished data, January 1988). Thus, taken as a whole, adolescent males in this

study—including the juvenile delinquent subjects—do not appear to be at nutritional risk when assessed by accepted measures of zinc, copper, and iron status. Therefore, no support is offered to allegations that the nutritional status of incarcerated male juveniles, as measured by a number of metabolic and anthropometric indices, is inferior to that of nonincarcerated male adolescents.

According to results of the preliminary analyses of the 3-day diet information, as a group, the subjects were consuming appropriate amounts of energy as compared with age-specific recommended dietary allowance values (Table 3). The proportions of macronutrients in the diets of subjects whose serum glucose was less than 2.8 mmol/L (group A) and those whose low serum glucose was greater than 3.3 mmol/L (group B) were not different. Furthermore, most subjects chose diets that are more than adequate in protein and fat and somewhat low in carbohydrate for their age range.⁵² In addition, the proportions of macronutrients shown in Table 3 are similar to those in the diets of the general US population of male adolescents.⁵³ Thus, differences in glucose response do not appear to be related to differences in immediate past intake. Detailed assessment of macronutrient and micronutrient content of all delinquent and nondelinquent subjects' diets, as well as discussion of issues of validity and reliability of the dietary information itself, will be described elsewhere.

Although we have shown evidence that there is a higher incidence of low serum glucose and high serum insulin in subgroups of delinquent subjects compared with nondelinquent subjects, we did not observe any associations between the adrenergic symptoms of true reactive hypoglycemia and excursions of either serum glucose or serum insulin. Therefore, no support is offered by this study either to speculations that reactive hypoglycemia is common in juvenile delinquent populations or to allegations that reactive hypoglycemia is associated with a history of juvenile delinquent behavior.

ACKNOWLEDGMENTS

This research was funded by the Food Research Institute, University of Wisconsin, Madison, and National Institutes of Health grant 5P30DK26659.

We appreciate the cooperation of the subjects who participated in this study, as well as the support and assistance of the administration and staff at both Ethan Allen School and the Madison Metropolitan School District high schools.

We thank June Stenner, phlebotomist, for her help in designing and implementing the blood drawing procedure. We are also grateful to Eileen Somers, Julie Nordlee and Terry Spennetta for performing the glucose, insulin, and thiamin analyses; to Dr Michael MacDonald for

critiquing the glucose/insulin curves; to Dr Janet Greger for providing technical assistance for the zinc, copper, and ferritin assays; to Sharon Nichols for helping to collect dietary and mood assessment information; and to Edwin Traisman for support and critical comment throughout the project.

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UNDERSTANDING V EXPLAINING NATURE

... There exist principally two types of scientists. The ones, and they are rare, wish to *understand* the world, to know nature; the others, much more frequent, wish to *explain* it. The first are searching for truth, often with the knowledge that they will not attain it; the second strive for plausibility, for the achievement of an intellectually consistent, and hence successful, view of the world. . . . At all times one could almost say that we can explain it all, but understand only very little.

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Submitted by Student