The Impact of a Low Food Additive and Sucrose Diet on Academic Performance in 803 New York City Public Schools

Stephen J. Schoenthaler, Ph.D.[1,4]
Walter E. Doraz, Ph.D.[2]
James A. Wakefield, Jr. Ph.D.[3]

Abstract

The introduction of a diet policy which lowered sucrose, synthetic food color/flavors, and two preservatives (BHA and BHT) over 4 years in 803 public schools was followed by a 15.7% increase in mean academic percentile ranking above the rest of the nation's schools who used the same standardized tests. Prior to the 15.7% gain, the standard deviation of the annual change in nation percentile rating had been less than 1%. Each school's academic performance ranking was negatively correlated with the percent of children who ate school food prior to the diet policy changes. However, after the policy transitions, the percent of students who ate school lunches and breakfasts within each school became positively correlated with that school's rate of gain ($r = .28$, $p < .0001$). (Int J Biosocial Res., 8(2); 185-195, 1986.)

Literature Review

Feingold[1] reported that 50% of childhood hyperactivity, learning disabilities, and other behavioral problems could be reduced by deleting synthetic food additives and natural salicylates from the diet. Yet, Conners[2] and Harley[3,4] were not able to confirm the Feingold hypothesis under double-blind placebo-controlled conditions using 26 mg of artificial food colors in each study. In contrast, Weiss[5] found limited support for the hypothesis when using 35 mg; the smallest child responded. Swanson and Kinsbourne[6] speculated that the discrepancy between Feingold's clinical observations and most controlled studies may have been due to insufficient levels of food colors in the test conditions. They found that the average child consumes 76 mg. of artificial food colors per day and 10% of the children exceed 150 mg. per day. Clearly, the 26 mg levels were too low. Swanson and Kinsbourne found that 17 out of 20 hyperactive children reacted adversely on learning tasks using 100 to 150 challenge doses. Equally important, none of the 20 non-hyperactive children in the control

Correspondence address:
[4]California State University-Stanislaus
801 W. Monte Vista
Turlock, CA 95380 U.S.A.

[1]Associate Professor, Department of Sociology
[2]Associate Professor, Department of Sociology
[3]Professor, Department of Psychology

group responded. In 1982, an independent panel of experts working for NIMH concluded that the elimination of synthetic food additives can lower behavioral problems in a small percent of the population for unknown reasons.[7] A re-analysis of the data presented in the early studies supported the NIMH position [8], but no consensus exists as to the size of the effected population nor the magnitude of the effects.[9,10]

The most convincing evidence to date is a three-phase study by Egger.[11] The first stage involved placing very hyperactive children on an oligoantigenic diet—one in which the number and types of foods is restricted to eliminate foods which may have a high allergy potential. Most children behaved better on the restricted diet. Suspect foods were randomly introduced back in to the diet in stage two. Sixty-two of the 76 children improved in stage one and responded negatively to selected foods in stage two. Synthetic food colorings and flavorings were the most common foods to which the children responded, but no child responded to food additives alone. Sixteen percent responded to sucrose.

The third stage eliminated the possibility of placebo effects—the power of suggestion—by using a double-blind placebo-controlled challenge design. The suspect foods were placed in pills. Identical capsules in appearance contained foods to which the child had not reacted in stage two. Neither the child nor the observer were aware which pills the child received during testing. Each child behaved significantly worse on the suspect foods under these conditions.

The applied institutional diet policy and juvenile delinquency literature supports Egger's clinical findings. A series of studies in 12 juvenile correctional facilities showed that deviant behavior fell 47% in a sample of 8,076 juveniles.[12] Approximately 20% of the youths were responsible for the 47% institution-wide declines in antisocial behavior.

The first Virginia studies [13,14] involved 276 delinquents who committed 934 offenses over two years inside a Tidewater detention facility. Behavior problems fell 48% during the year following the diet policy changes. Violence declined 33% (n=73 incidents), theft dropped 77% (n=37 incidents), insubordination fell 55% (n=197), "horseplay" or hyperactivity was cut 65% (n=145), and the remaining infractions declined 30% (n=145 incidents).

Three Los Angeles County probation detention halls found a 44% reduction in official misbehavior in 1382 youths who served as their own controls.[15] In a separate study, violence fell 25% and horseplay declined 42% in a northern California probation department facility following similar diet policy revisions.[16] Suicide attempts within these California sites fell 44% (n=29).

Other juvenile facilities in Coosa Valley, Alabama and Fairfax County, Virginia improved on the earlier designs by returning to their previous diet policies temporarily.[17,18] The Alabama site in Coosa Valley found that behavior problems in 39 experimental youths were 45% lower than the 21 previous or 21 subsequent control group youths in an a-b-a design. Twenty-eight subjects who served as their own controls exhibited a 35% lower rate of behavior problems on the revised diet. Diet order made no difference in these 28 juveniles.

The Fairfax County detention center study was more complex. The protocol involved an a-b-a-b-a design and 1,150 youths over two years. Fifty-seven per-cent of the three control groups were involved in antisocial behavior in contrast to 43% of the two experimental groups. A follow-up seven day diet analysis on each youth within this site strongly suggests that the reduction of pre-existing malnutrition prior to arrival may have been the cause of many behavior problems.

A statewide adoption of similar institutional diet policies in Alabama's Department of Youth Services facilities supports this interpretation.[18] During the 18 months prior to the diet policy modifications, antisocial behavior levels remained stable. For four-and-a-half months following the diet policy change, behavior problems gradually fell and then leveled off for the next 14 months 61% lower than the levels prior to policy modification.

The gradual improvement in behavior over four-and-a-half months suggests that the slow elimination of previous malnutrition may have been the primary cause of the improvements. If the changes were due to placebo effects, the decline in behavior problems should have been immediate and sharp followed by a gradual rise as placebo effects started to wear off. If the improvements were primarily due to the elimination of food intolerances ("allergies"), the changes should have shown up in a few days rather than gradually over four-and-a-half months.

Seven day diet analyses in two California Youth Authority sites followed by double-blind placebo-controlled nutrient supplementation have confirmed the malnutrition hypothesis.[18,19,20] Malnourished delinquents cause more behavioral problems than adequately nourished delinquents. Furthermore, the level of antisocial behavior in malnourished delinquents can be lowered significantly by low level supplementation of selected nutrients under double-blind placebo-controlled conditions. These results do not invalidate the previous findings that selected children are "allergic" to sucrose, synthetic food colors, and/or synthetic food flavors. Rather, these data confirm that diet-behavior relationships have multiple causes and multiple effects.

According to The Feingold Association[21], the Feingold diet may also eliminate "cognitive and perceptual disorders such as auditory memory deficits; difficulties in reasoning (e.g. simple math problems, meanings of words); difficulty in comprehension; [and] disturbances in spatial orientation (up-down; right-left)." Unfortunately, there has been little if any hard data to verify or refute this claim. Most of the previous research in the field of diet and behavior has focused on the issues of hyperactivity or juvenile delinquency. Generalizations from chronic delinquents and/or hyperactive children to public schools is premature for two reasons: First, the populations are different. Few public school children are highly overactive or delinquent. What works for a select sample of children may have no observable impact in public schools. Second, the magnitude of the effect of diet on hyperactivity and delinquency may be too small to have a significant effect on school-wide academic performance even though both hyperactivity and delinquency are inversely correlated with academic scholarship.

The Office of School Food and Nutrition of The New York City Board of Education decided to test what effect, if any, that modifying selected nutritional policies would have on academic performance, attendance, and delinquency in New York Public Schools. In essence, the Chief Administrator, Dr. Elizabeth Cagan, Ed.D., implemented "phase one" of The Feingold Diet throughout New York City Public Schools and waited to determine the behavioral consequences, if any.

Methods

The diet consisted of the gradual elimination of synthetic (artificial) colors, synthetic (artificial) flavors, and selected preservatives (BHA and BHT). At the same time, high sucrose foods were gradually eliminated or else the quantity of sucrose was reduced by setting specific maximum limits on selected foods such as ice cream and cereal. When each revision was implemented, the changes took place simultaneously in all schools. However, all the necessary modifications did not occur during one year. The revisions took place during the 1979-80, 1980-81 and 1982-83 academic years. No changes were made during the 1981-82 academic year. The interrupted implementation of the new diet policies fits well with a traditional quasi-experimental interrupted time-series design.[22,23]

Each of the selected schools gave The California Achievement Test (CAT) each year from which the mean national percentile rank of the school was determined. The unit of analysis became the change in national academic percentile ranking between adjacent years for each school when giving the same achievement tests in both years. Operationally this involved four steps: (1) the mean academic CAT score for each school was calculated; (2) the mean was converted to a national percentile ranking by comparing the mean to other U.S. schools who used the same test that year; (3) the previous year's national percentile ranking was subtracted from the current year's to determine this year's gain/loss in national percentile ranking; and (4) the gain or loss of all 803 schools was averaged together for each year to create a mean gain or decline in national percentile ranking for 1977 through 1983. Data was available for the four years before and after the initial changes in 1979.

Results

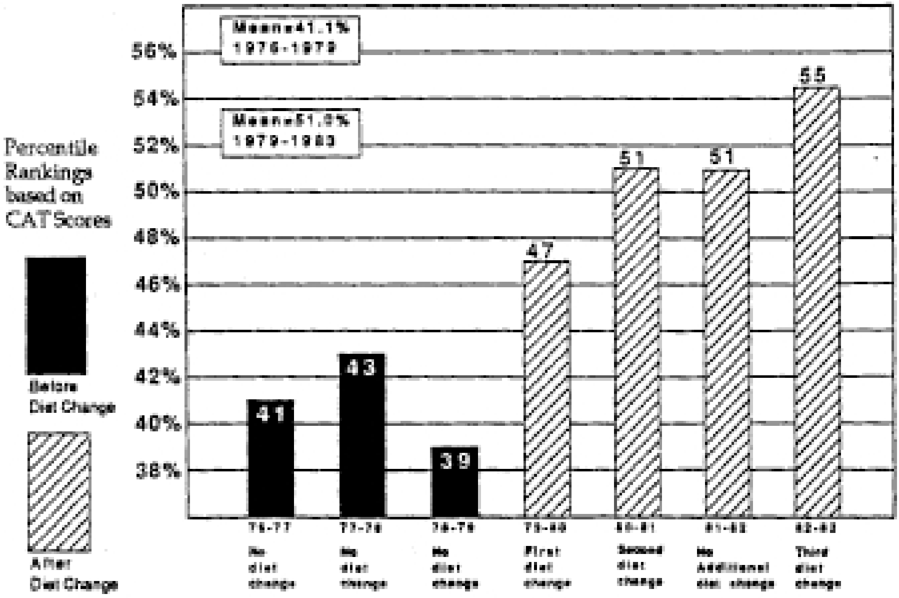
Before the diet change, very little change occurred in mean academic percentile rank for the 803 schools. The average fell just less than 1% per year (mean = -.95%, s.d. = .94%, range = 2.7%). The only year with a gain was 1977-78 and that was limited to 1.7%. The mean national performance rankings of the 803 public schools stood at 39.2% in the spring of 1979.

The first major diet policy revisions restricted sucrose levels to 11% in all foods during the fall of 1979. Two synthetic food colors were also eliminated. In the spring of 1980, mean national percentile rank rose to 47.3%—an 8.1% increase (s.d. = .20). During the 1981 academic year, the remaining foods containing synthetic colors and all foods with synthetic flavors were eliminated. Rank increased 3.8% to 51.2% (s.d. = .10).

During 1982, no further revisions were made. Mean national percentile rank declined slightly to 50.8% (s.d. = .01). However, when foods containing BHT and BHA were eliminated during the fourth year, rank increased to 54.9—a 3.7% increase (s.d. = .20).

Table 1.

National Rankings of 803 New York City Public Schools Before and After Diet Changes



In short, New York City Public Schools raised their mean national academic performance percentile ranking 15.7% (from 39.2% to 54.9%) in four years with the gains occurring in the 1st, 2nd and 4th years. The academic gains in these three years propelled New York City schools from 11% below the national average to 5% above the mean.

All children did not improve equally. Part of the improvement may be explained by the decline in "learning disabled" children and/or "repeat failures." In 1979, 12.4% of the one million student sample were performing two or more grades below the proper level. Yet, by the end of the 1983 year, the rate had dropped to 4.9%. Again, all gains were found during 1980, 1981, and 1983.

Quasi-experimental time-series designs are effective measures of before-after change for institutional settings. However, in these designs, one may not know if the desired results are due to the manifest independent variable (diet policy in this case) or latent causative variable(s) which were introduced simultaneously with the three diet changes.[22,23]

Table 2.

Mean Gain in School Academic Rank and Percent of Student Involvement for the "Best Control" Year (1977-1978) Before Diet Revisions.

Percent of Students Receiving School Food	Mean Academic Gain Per Year	Standard Deviation	# of Schools
00.0 to 10%	1.7	6.4	55
10.1 to 20%	1.5	4.3	47
20.1 to 30%	2.6	4.3	62
30.1 to 40%	2.2	4.0	65
40.1 to 50%	2.2	[illegible]	63
50.1 to 60%	2.6	6.4	76
60.1 to 70%	3.0	12.3	77
70.1 to 80%	2.2	5.8	102
80.1 to 90%	1.7	8.8	123
90.1 to 100%	-0.6	10.8	133

(mean gain = 1.7 for best control year)
($r = -.068$, $n = 803$, $F = 1.793$, $p = .06$)

This rival hypothesis was empirically tested by comparing the percent of students who received school lunches/breakfasts in each school with the mean academic percentile gain for that school before and after the diet policy changes. Prior to the diet changes, a weak negative correlation between school food consumption and academic performance existed ($r = -.068$). In contrast, a significant positive correlation was found after the diet change ($r = .279$ and $p = .0001$).

Table 3.

Mean Gain in School Achievement Rank and Percent of Student Involvement for Four Years After Diet Revisions.

Percent of Students Receiving School Food	Mean Academic Gain Per Year	Standard Deviation	# of Schools
00.0 to 10%	4.4	12.3	29
10.1 to 20%	6.5	3.6	21
20.1 to 30%	7.4	4.8	46
30.1 to 40%	8.3	4.4	48
40.1 to 50%	8.4	5.5	55
50.1 to 60%	7.5	6.8	70
60.1 to 70%	8.7	6.0	79
70.1 to 80%	10.7	6.4	132
80.1 to 90%	11.7	7.9	161
90.1 to 100%	12.2	7.6	162

(mean gain = 9.9 for 4 experimental years over 3 control years)
($r = .2788$, $n = 803$, $F = 8.301$, $p < .0001$)

The examination of attendance rates and delinquency yielded little of significance. The measure of delinquency—number of children expelled per semester per school—furnished by The Board of Education did not pass the test of stability. For example, one school had 18 expulsions in the Fall followed by 2 in the Spring, 8 the following Fall and 27 the following Spring. Campbell[22] called this type of measurement problem "lack of stability." A review of sixty schools turned up none that showed stability in the reporting of delinquency. Testing of the delinquency hypothesis was abandoned for this reason.

In contrast, attendance rates were very stable. The number of students present each month divided by the number enrolled became the attendance rate for each school each month. Significant differences were found between months of each academic year. Apparently, the different seasons and holidays have a considerable impact on attendance. However, a comparison of yearly attendance rates before the diet policy changes showed little variation in annual attendance rates (s.d. = .04). After the diet policy changes, attendance climbed one-tenth of one percent—an amount which was not significant. The nutritional policies did not appear to impact attendance.

Discussion

Several conclusions are apparent. First, there is no doubt that national academic performance rankings increased significantly above the rest of the nation at the end of 1980 (8.1%), 1981 (3.8%), and 1983 (3.7%). Second, the major diet policy modifications took place at or near the beginning of these three academic years. Third, slight declines were evident during three of the four control years—1977, 1979, and 1982. Fourth, a slight but significant gain (1.7%) occurred during the fourth "control" year—1978.

There are two different criteria which one can use to classify the seven years as experimentals or controls. If one selects only those years which involved a major change recommended by the Feingold Diet as experimental years, then 1980, 1981, and 1983 would be the three experimental years and 1977, 1978, 1979, and 1982 would be the control years. When one uses this classification model the academic improvements fit with every year except 1978.

Although the 1977-1978 year was labelled a "control" year using the Feingold Diet as a standard, a review of The Office of School Food and Nutrition food requirements showed that a major dietary policy revision occurred in November of 1977. The level of fat allowable in the diet was cut significantly. If one labels each year as an experimental or control year based on whether or not Dr. Elizabeth Cagan's Office made major nutritional policy revisions, then the academic improvements fit with all seven years. More specifically, the four years which showed gains in national ranking were the same four years in which the Office of School Food and Nutrition made major dietary policy revisions involving sucrose, fats, and food additives.

This congruence may be causative or coincidental. The probability of the relationship being spurious appears to be unlikely: a comparison of the percentage of children who ate school food and that school's change in national percentile ranking showed a significant positive correlation after the 1979 diet policy changes, but not before.

Quasi-experimental designs take a radically different approach to research from classical experimental designs. A hypothesis is viewed as valid until at least one rival plausible explanation can be found.[24] In order to invalidate the conclusion that diet policy was the causative agent, one must create a theory capable of simultaneously explaining: (1) why significant gains in national percentile ranking appeared during the years when nutritional intervention occurred—1978, 1980, 1981, and 1983; (2) why minor declines occurred in all other years—1977, 1979, and 1982; (3) why the percentage of students eating school food in a given school before 1979 is inversely correlated with changes in national academic performance percentile ranking; and (4) why the percentage of students eating school food in a given school after 1979 is directly correlated with changes in national academic performance percentile ranking. The authors know of no rival explanation which can account for these findings. Unless other investigators find an explanation for these four observations, the conclusion that diet policy was responsible for academic gain must stand.

One question remains. Was the change in performance due to: (1) the combination of restricting (a) food additives, (b) sucrose, and (c) fat; or (2) an unidentified factor which is correlated with all three such as malnutrition. Lay people might be tempted to conclude that sugar and food additives directly caused the poor grades with the fat being the least important. Most nutritionists would reach a different conclusion. A reduction in malnutrition—rather that a reduction in sugar, fats, and food additives—is probably the primary cause of the improved academic performance for three reasons.

First, a common factor exists in foods which contain high levels of fats, sucrose, and food additives. They tend to be low in the ratio of essential nutrients to calories. Foods which are laden with synthetic food color/flavors tend to be the more processed foods, which in turn, have lost a substantial portion of their nutritional value in processing. Pure sucrose, by definition contains no nutrients other than four calories per gram. Fat contains a few nutrients but has even more calories per gram—nine. When the consumption of "empty calories" (sucrose, fats, and processed foods) decreases, children normally eat other foods which contain a higher ratio of nutrients to calories. The uptake in foods which are more nutritious should lower any malnutrition which existed.

Second, a substantial body of research supports the link between malnutrition and academic behavior in controlled laboratory studies.[25-28]

Third, the available data published in major journals which directly implicates food additives and sucrose consistently have reported negative findings in general or else positive findings on a very select population.[2-11]

Davis[29] has suggested that the high consumption of sucrose, fat, and "dismembered" (highly processed) foods will result in less than optimal nutrition and may lead to marginal malnutrition. The policies which eliminated non-essential food additives coincidentally restricted dismembered foods and resulted in an uptake of nutrient-dense foods. The policies that restricted sucrose and fat would have had the same result. It makes more sense to explain the widespread gain in academic performance using one variable—malnutrition—which can affect every student's performance rather than idiopathic sucrose and food additive "allergy" which tends to affect a very small proportion of the population.

Improvements in academic performance by comparison with other U.S. schools during the same time period appear to be due to the diet policies which restricted fats, sucrose, and food additives. The cause(s) will remain unverified without further research, but malnutrition may be the predominant causative variable since all students have the potential of being malnourished. Although malnutrition appears to be the most likely theoretical explanation for most of the improvements, selected children may have improved due to a restriction of food additives and sucrose which cause "allergy" symptoms.

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Biographical Notes

Stephen J. Schoenthaler, Ph.D., is an Associate Professor of Sociology in the Department of Sociology at California State University-Stanislaus, in Turlock, California. He earned his Ph.D. in Sociology with emphasis on research methodology at the State University of New York (SUNY) at Buffalo. He has been an Assistant Professor of Sociology at both Virginia Wesleyan College and the University of Southern Mississippi.

Dr. Walter Doraz, Ph.D., is an Associate Professor of Sociology in the Department of Sociology at California State University-Stanislaus, in Turlock, California. He received his Ph.D. in Sociology from Washington State University in Pullman, Washington. He is Coordinator of the Gerontology Program at the University, where he teaches and conducts research on aging, alcoholism and nutrition and behavior.

Dr. James A. Wakefield, Jr., Ph.D., is a Professor of Psychology in the Department of Psychology at California State University-Stanislaus, in Turlock, California. He received his Ph.D. in Psychology from the University of Houston, Houston, Texas.