Journal of Nutritional & Environmental Medicine (1997) 7, 343–352

CARFAX

FOOD, BRAIN and BEHAVIOUR
Conference Proceedings October 1996
ALLERGY RESEARCH FOUNDATION

The Effect of Randomized Vitamin–Mineral Supplementation on Violent and Non-violent Antisocial Behavior Among Incarcerated Juveniles

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In a randomized controlled double-blind trial, the effects of vitamin–mineral supplementation on violence and other serious antisocial behavior were studied for 3 months on 62 confined delinquents aged 13 to 17 years. A significant difference between 32 active and 30 placebo subjects was found for violent and non-violent antisocial behavior. The net difference in rule infractions between the active and placebo groups in violence was 28% (95% confidence interval 15–41%). This direction and magnitude of effect were seen with both violent and non-violent rule violations. Twenty-six habitually violent subjects donated pre- and post-intervention blood samples. Among 10 subjects who maintained their normal or low blood concentrations of vitamins throughout the trial, there was no marked change in violence (i.e. 39 acts during baseline and 37 during intervention). In contrast, the 16 subjects who corrected their low blood vitamin concentrations during intervention produced 131 violent acts during baseline and 11 during intervention. The correction of low blood vitamin concentrations with vitamin–mineral supplements improves brain function and significantly reduces violence among delinquents confined in correctional facilities.

Keywords: nutrition, diet, vitamin–mineral supplementation, behavior, crime, delinquency.

INTRODUCTION

There have been reports of open trials in which dietary changes made in prisons have been followed by a significant reduction in violence and other serious rule infractions [1–6]. The dietary changes increased nutrient density by replacing high fat and sugar foods with fruits, vegetables and whole grains in proportions recommended by the National Academy of Sciences' Food and Nutrition Board [7]. These findings raised the hypothesis that a balanced healthy diet—rich in essential vitamins and minerals owing to ample fruits, vegetables and whole grains—could correct low blood concentrations of the nutrients essential for proper brain function [8] and, thus, reduce violence owing to malnutrition [4]. Unfortunately, none of the studies in correctional institutions used proper control groups, random selection, nutritional assessment, or control for psychological effects as reported in

1359-0847/97/040343-10 $9.00

state-of-the-art nutrition and behavior research [9]. The following report describes a study that overcomes these limitations.

METHODS

Site and Subjects

The study was conducted in a psychiatric-oriented medical facility that houses juvenile delinquents in a maximum security setting. All 71 residents, male and female, volunteered to participate in the presence of an ombudsman after parental and judicial consent were given. The site held this mid-western state's youthful 'chronic offenders', the 6% of the population that commits more than half of the murders, rapes, robberies and assaults in Great Britain [10] and the US [11]. Psychiatric assessment showed multiple psychological problems and confirmed the repeat delinquency among these residents aged 13 to 17 years.

Dietary Assessment

A 7-day dietary survey was done on each resident in the form of a plate-waste analysis. Each resident received standardized portions of known weights at each meal under the supervision of a registered dietician. She calculated consumption by measuring how much was left of each portion. Residents were allowed to have second portions from kitchen personnel after recording the request with the dietician. Swapping of foods was prohibited and enforced at meals by staff. Between-meal snacks were self-reported by residents daily and scrutinized for completeness. The University of California, Berkeley's 'Food2' program was utilized to measure mean daily intake of calories, protein, fat, starch, sucrose and 14 micronutrients from the data.

Nutritional Assessments

Nutritional status was also assessed with pre- and post-laboratory tests and physical examinations that focused on clinical signs of nutritional deficiencies by the registered dietician under the supervision of a qualified doctor. Weight, height and any physical signs of poor nutrition were recorded. When clinical signs of deficiencies were found, the registered dietician showed each resident the signs with a mirror and counseled each about dietary changes that could correct the conditions found on the tongue, hair, face, eyes, lips, gums, skin or nails [12, 13]. The dietician, who was blind to group assignment, simply counseled every subject as if he or she was in the placebo group. Which subjects changed their diets was confirmed at the end of the study with a follow-up physical examination, laboratory tests and another plate-waste analysis.

Dependent Variables

For a 13-week baseline and 13-week experimental period, rule violation reports were used to construct three indices of crime:

(1) violent rule infractions;
(2) non-violent rule infractions;
(3) total rule infractions.

These measures of institutional crime have been validated by the Bureau of Justice Statistics (BJS) [14]. Whenever a prison rule is violated that may result in a lengthening of incarceration, detailed documentation is required. These reports are the raw data that the BJS (a division of the US Department of Justice) uses to monitor institutional rule violations. Based on its most recent survey [14], the BJS estimates that about 34% of all inmates commit more than 1 infraction per year, about 20% commit two to five incidents,

6% commit six to ten incidents, and 8% commit 11 or more. Roughly one-third are violent. The distribution of violent rule infractions among the 71 residents closely matched the national pattern except that the same magnitude was achieved monthly, not yearly, owing to the chronic nature of their violence.

Randomization and Sample Selection

A stratified randomized design was used based on individual violence rates for the 13 weeks before intervention. Three of the 71 residents were excluded from the data analysis because their baseline confinement was too short to generate reliable measures, i.e. under 1 month. Two were excluded because of 'floor-effects'; i.e. they could not improve since they committed no violations during the baseline. The remaining 66 residents were matched on baseline violence rates and then randomly allocated to the active or placebo group. Four residents were subsequently excluded; one owing to a change in psychotropic medication and three who were paroled during the first month of the trial since this period had already been deemed to be too short to be reliable. The remaining 32 on active and 30 on placebo were included in the data analysis.

Tablet Administration

The tablets consisted of one vitamin pill given each morning and two mineral pills given each evening. Institutional nursing staff distributed the pills daily for the 13-week period during their morning and evening medical rounds. Neither the research nor institutional staff knew any subject's group assignment.

Supplements

The placebos and supplements were compared for appearance, odor and taste by 20 university students. Ten guessed wrong when asked to identify the placebos. At the end of the trial, each resident was asked by the second author to guess whether he or she had received a placebo or an active tablet. No relationship was found between group assignment and resident guess. The supplements contained 12 vitamins and 11 minerals set at about 100% of the US recommended daily allowance (RDA) for minerals and 300% of the US RDA for most vitamins. The amounts of calcium (122 mg), magnesium (59 mg) and vitamin D (200 IU) were lower. Only the amounts of vitamin C (120 mg) and pyridoxine (30 mg) were higher than 300%. Vitamin A and folate were set at the US RDA. The supplements also contained 50 mg of *p*-amino benzoic acid, 40 mg of inositol and 40 mg of choline; these were donated by Klaire Laboratories of California as a non-commercial formulation for the study.

Statistics

Most residents were confined for the entire 13-week baseline and experimental periods. Mean lengths of baseline and experimental confinement averaged 12 weeks, but ranged from 4 to 13 weeks. To control for different lengths of time during which residents were at risk of committing rule infractions, the unit of analysis became the mean weekly baseline and experimental rates. Means were calculated for each time period on each resident by summing the violations and dividing by the weeks of confinement. Violent infractions, non-violent rule infractions and total rule infractions for the experimental period became the three dependent variables. The same variables during the baseline period served as co-variates. Since the trial was a randomized parallel group trial with pre- and post-tests, the appropriate analysis was analysis of covariance with the logged violation rates during the treatment period as the dependent variable, treatment group (active versus placebo) as

TABLE 1. Nutrient intakes (mean, SD)

	Boys		Girls	
Intake	Intake	US RDA (%)	Intake	US RDA (%)
Energy (kcal)	8824 (2390)	74	8400 (2713)	82
Protein (g)	78 (25)	124	62 (17)	93
Fat (g)	99 (33)	129	77 (19)	115
Starch (g)	225 (56)	62	260 (111)	80
Sucrose (g)	70 (48)	135	67 (59)	134
Iron (mg)	11 (4)	63	11 (4)	64
Calcium (mg)	1192 (598)	104	877 (492)	79
Zinc (mg)	6 (3)	39	6 (3)	38
Magnesium (mg)	166 (74)	42	147 (58)	49
Phosphorus (g)	1.4 (0.5)	115	1.1 (0.4)	92
Vitamin A (μg)[a]	1233 (481)	83	1053 (380)	82
Vitamin B_1 (mg)	1.5 (0.5)	108	1.2 (0.5)	107
Vitamin B_2 (mg)	2.3 (0.9)	138	1.7 (0.6)	123
Vitamin B_3 (mg)[b]	14 (5.2)	80	12 (3.5)	84
Vitamin B_6 (mg)	0.7 (0.3)	39	0.8 (0.3)	37
Vitamin B_{12} (μg)	2.3 (0.9)	125	1.8 (0.8)	86
Total folate (μg)	137 (68)	34	140 (59)	35
Vitamin C (mg)	94 (60)	153	102 (49)	162
Vitamin D (μg)	8.6 (4.7)	86	5.5 (3.5)	55

[a]Retinol equivalent.
[b]Nicotinic acid equivalent.

the factor, and the logged rates during the pre-treatment time as a covariate. The treatment effect of supplementation, which would be adjusted for baseline differences, became the primary variable of interest. The violation rates were normalized using log 10 transformations owing to substantial skewing of the original distributions.

We also hypothesized that the underlying cause of supplementation producing a reduction in violence was the correction of low blood nutrient concentrations that were impairing brain function. Hence, the second analysis was done with correction or maintenance of pre-test blood vitamin concentrations as the factor of primary interest. These analyses used analysis of covariance with the logged violation rates during the treatment period as the dependent variable and the logged rates during the pre-treatment time as a covariate.

RESULTS

The mean daily nutrient intakes of the residents who completed the plate-waste and snack analysis satisfactorily are shown in Table 1 which also displays the mean daily percentage of the US RDAs [7]. Five findings emerged. Firstly, the intake of starch—fruit, vegetables and grains—were low and the intake of fat and sucrose was high. This supports the international trend in correctional institutions to reduce fat/sucrose and to expand fruit, vegetable and whole grain consumption. Secondly, these imbalances were more pronounced in males than females which is consistent with males being four times as violent, on average, as females [15]. Thirdly, the average energy consumption in Table 1 is low while the weight and height (Table 2) are normal for children aged 13 to 17 years [12]. The discrepancy between caloric intake and weight is consistent with previous findings that delinquents and adult criminals have normal weights but lower caloric intakes explained by lower physical exercise [4]. Fourthly, a comparison of the 14 micronutrient intakes is similar to a 10-state US survey [16] and a national British survey [17]. In all three cases, low intake was the most widespread in the vitamins—thiamin, pyridoxine and folate—and the minerals—iron, zinc and magnesium—but was not restricted to these nutrients alone. Fifthly, although the mean nutrient intakes are similar to typical British schoolchildren

TABLE 2. Initial characteristics

Parameter	Active 32 ($n = 32$)	Placebo ($n = 30$)
Boys/girls	23/9	18/12
Age (years)	15.2	15.2
Height (cm)	165.0	163.0
Weight (kg)	66.2	70.2
White/other	22/10	26/4
On medication	43%	54%
DSM III diagnosis of 'Aggressive'	45%	40%

aged, on average, 12 years [9], the standard deviations are much larger producing greater threats to nutritional integrity among the delinquents. For example, the sucrose consumption ranged from 8 to 47% of daily caloric consumption among the delinquents.

The active and placebo groups were similar in initial characteristics that have been related to nutritional status or criminal behavior (Table 2). There were also no significant differences in drug/alcohol abuse, number of prior arrests or length of confinement during the baseline period. Owing to careful matching on baseline violence rates and an attrition rate of only four subjects, it is not surprising that mean baseline differences in violence were only 0.017 incidents per week (Table 3). In fact, none of the initial differences in behavior was significantly different (Table 4).

The effect of supplementation is assessed in Table 4. The interaction was significant on each measure. Violence fell, on average, 80% in the active group and 56% in the placebo group. Non-violent rule violations fell 83% among the active group and 49% in the placebo group. Total rule violations fell 83% among the supplement group and 55% among the placebo group, a net difference of 28% (95% confidence interval 15–41%).

The protocol for defining deficiency for each blood nutrient concentration was based on research by Chandra [18]. In both studies, blood samples were gathered from an independent source for the purpose of defining blood nutrient deficiency in a manner that could be subsequently tested on the experimental sample. Chandra identified subjects who were acceptable on his primary variable of interest (no immune system-based health problems) and defined deficiency as those blood values below the 95% confidence interval surrounding the mean of each nutrient. In this research, subjects aged 13 to 17 years were identified in another prison who were acceptable on the primary variable of interest: no violent institutional rule violations while confined at least 13 weeks. Blood was drawn and assayed on this independent sample. Any blood nutrient concentration below the range was selected

TABLE 3. Mean rates per subject for three measures of crime by group and condition[a]

Type of serious rule infraction	Baseline		Experimental		Change		Net difference
	Active	Placebo	Active	Placebo	Active	Placebo	
Violent rule infractions	0.389	0.372	0.078	0.163	0.311	0.209	0.10
Non-violent rule infractions	3.05	2.57	0.515	1.03	2.54	1.27	1.3
Total rule infractions	3.44	2.94	0.587	1.31	2.85	1.63	1.2

[a]Means reflect the number of infractions divided by number of weeks confined for each resident.

TABLE 4. Summary of the analysis of variance and covariance for three indices of crime within a prison setting using $\log_{10}$ transformations

	Differences in initial rates between groups		Treatment effect adjusted for baseline differences	
Indices	*F*	*p*	*F*	*p*
Violent rule infractions	0.0013	0.9710	4.236	0.044
Non-violent rule infractions	0.1608	0.6898	7.646	0.008
Total rule infractions	0.1537	0.6965	8.517	0.005

as the definition of deficiency (Table 5) rather than the 95% confidence range that Chandra used.

Among the 26 residents who exhibited multiple violent acts during the baseline, and donated both pre- and post-intervention blood samples, there were no deficiencies of any minerals and four vitamins: riboflavin, B_{12}, A and E. However, there were 36 pre- and eight post-deficiencies of vitamin C, thiamin, niacin, pantothenic acid, pyridoxine and folic acid. Their distribution is illustrated in Table 6 for subjects who did not improve dramatically and in Table 7 for subjects who did improve dramatically.

The change in low blood concentrations was then examined among 10 subjects who showed no meaningful change in violence during the trial. More specifically, Table 6 shows four residents on placebo who produced 18 violent attacks during baseline and 17 during intervention. These four residents showed six baseline deficiencies and six deficiencies after intervention. Table 6 also shows six residents who had 0 low blood vitamin concentrations

TABLE 5. Nutrient ranges among 24 delinquents with no evidence of violence while incarcerated

Vitamin/mineral	Sample/method	Ranges	Unit
Vitamin A	S/functional	20–54	μmol l^{-1}
Vitamin E	S/functional	0.47–1.3	μmol l^{-1}
Vitamin C	S/functional	0.55–1.4	mg dl^{-1}
Thiamin	W/micro	26–39	ng ml^{-1}
Riboflavin	W/micro	184–447	ng ml^{-1}
Niacin	W/micro	3.0–7.3	μg ml^{-1}
B_5	W/micro	142–468	ng ml^{-1}
Pyridoxine	S/micro	29–74	ng ml^{-1}
B_{12}	S/micro	387–973	μg ml^{-1}
Folates	S/micro	3.6–5.2	ng ml^{-1}
Calcium	W/AAS	49–73	ppm
Magnesium	W/AAS	29–39	ppm
Copper	W/AAS	0.62–0.96	ppm
Iron	W/AAS	365–524	ppm
Zinc	W/AAS	3.4–7.2	ppm
Selenium	W/AAS	0.08–0.15	ppm
Manganese	W/AAS	0.012–0.019	ppm
Chromium	W/AAS	0.020–0.061	ppm

AAS = atomic absorption spectrophotometry.
micro = microprotozoan. S = serum. W = whole blood.

during the baseline and 0 after intervention. They too produced no meaningful reduction in violence (i.e., 21 violent attacks during baseline and 20 during the experimental phase). Thus, Table 6 shows that intervention did not reduce deficiencies among the 10 subjects whose violence did not decline substantially (i.e. 39 to 37 acts). These data suggest that there is no effect of nutritional intervention on violence unless low blood nutrient concentrations are present and corrected.

In marked contrast, the 16 residents who produced the greatest decreases in violent attacks, (i.e. 131 to 11) had 30 low blood concentrations at baseline and just two at the end of intervention (Table 7). The magnitude of the differences in violence reduction within these two tables (i.e. 39 to 37 versus 131 to 11) suggests a strong relationship between lowering violence and correcting low blood vitamin concentrations.

To test this secondary hypothesis, all subjects who had low blood vitamin concentrations that became normalized by the end of the intervention period, regardless of group assignment or diet change, were compared with all subjects who maintained low blood vitamin concentrations throughout the study or had no evidence of pre-intervention low blood vitamin concentrations. As expected, the 18 subjects with blood vitamin concentrations that became normal at the post-test produced significantly less violence than the 16 subjects who did not ($F1$, 31; 12.619, $p < 0.001$, 1-tail test). (The difference between this analysis and Tables 6 and 7 is the inclusion of eight subjects who produced zero or only one violent act during baseline.)

The 56% reduction in violence among the placebo group should not be attributed to widespread placebo effects. Twenty-four placebo subjects, who did not improve their diets, produced no reduction in violence (i.e. 51 pre-intervention acts and 52 during the intervention period). The remaining six subjects on placebo improved their diets by decreasing fat and sucrose consumption, and increasing fruit, vegetable and whole grain consumption. The 56% reduction in the placebo group's violence was due to improvements in the behavior of these six subjects whose violence fell from 74 to six acts. At the pre-test, these six subjects had 13 blood deficiencies; however, at the post-test, just one deficiency remained.

DISCUSSION

There is empirical evidence to support the conclusion that this intervention improved brain function on this population; we previously published the results of brain electrical activity mapping on six of the more violent children [19]. Among two placebo subjects, there were eight EEG baseline abnormalities and eight at the end of intervention under the same test conditions in the same region and the same direction of abnormality. In contrast, the number of abnormalities among four subjects on active tablets fell from 14 to two. Thus, we have demonstrated in this paper that vitamin–mineral supplementation raises low blood vitamin concentrations, corrects abnormal brain function owing to low blood vitamin status, and ultimately produces better behavior and less violence among juvenile delinquents.

The 28% mean difference between the groups would have been closer to 50% if a nutritional assessment and counseling had not been given to all offenders. This appears to have caused massive improvements in six placebo subjects.

The data on the first 12 subjects in Table 6 may suggest that supplements are not necessary when residents are given a thorough nutritional assessment and counseling by qualified personnel who adequately motivate the residents to take responsibility for selecting a good diet. The literature suggests that about a 45% reduction in violence is possible by diet change alone [1–6].

This study shows not only that vitamin–mineral supplements reduce crime in institutional settings, but also that lowering fat and sucrose to levels suggested by the British and American governments, for health reasons, may reduce crime owing to vitamin–mineral uptake. However, it would be inappropriate to extrapolate the changes in behavior described

TABLE 6. Low pre- and post-test blood vitamin concentrations in 10 repeat violent offenders who did not improve dramatically

Subject	Group	Change in diet	Violence		C		B_1		Niacin		B_5		B_6		Folates	
			Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	P	No	5	6	—	—	—	—	—	—	—	—	—	26	2.8	2.7
2	P	No	4	4	—	—	22	—	—	—	—	—	23	28	3.1	3.0
3	P	No	6	4	—	—	—	—	—	—	—	—	—	28	3.0	—
4	P	No	3	3	—	—	—	—	—	—	—	—	20	22	—	—
5	P	No	2	5	—	—	—	—	—	—	—	—	—	—	—	—
6	P	No	5	5	—	—	—	—	—	—	—	—	—	—	—	—
7	P	No	5	4	—	—	—	—	—	—	—	—	—	—	—	—
8	A	No	3	2	—	—	—	—	—	—	—	—	—	—	—	—
9	A	No	3	2	—	—	—	—	—	—	—	—	—	—	—	—
10	A	No	3	2	—	—	—	—	—	—	—	—	—	—	—	—
Totals		0	39	37	0	0	1	0	0	0	0	0	2	4	3	2
Below the range of Table 5 non-violent juveniles					<0.55 mg/dl		<26 ng ml^{-1}		<3.0 μg ml^{-1}		<142 ng ml^{-1}		<29 ng ml^{-1}		<3.6 ng ml^{-1}	

A = Active. P = Placebo. — = normal.

TABLE 7. Low pre- and post-test blood vitamin concentrations in 16 repeat violent offenders who improved dramatically

Subject	Group	Change in diet	Violence		C		B_1		Niacin		B_5		B_6		Folates	
			Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	P	Yes	23	1	—	—	—	—	—	—	—	—	25	—	—	—
2	P	Yes	18	1	—	—	24	—	—	—	—	—	—	—	3.3	—
3	P	Yes	9	0	—	—	—	—	—	—	128	—	—	—	3.4	—
4	P	Yes	6	0	—	—	22	—	—	—	—	—	20	26	3.2	—
5	P	Yes	8	2	0.50	—	—	—	—	—	—	—	14	—	3.3	—
6	P	Yes	10	2	—	—	22	—	—	—	—	—	23	—	—	—
7	A	Yes	18	1	—	—	—	—	—	—	—	—	27	—	—	—
8	A	Yes	9	0	—	—	24	—	—	—	—	—	—	—	—	—
9	A	Yes	6	0	—	—	19	—	—	—	—	—	—	—	3.4	—
10	A	Yes	5	0	—	—	—	—	—	—	122	—	—	27	—	—
11	A	Yes	6	2	0.34	—	—	—	—	—	—	—	25	27	—	—
12		Yes	3	0	—	—	—	—	2.8	—	—	—	25	—	—	—
13	A	No	4	2	—	—	—	—	2.8	—	—	—	25	—	3.0	—
14	A	No	2	0	—	—	25	—	—	—	—	—	—	—	3.4	—
15	A	No	2	0	—	—	—	—	—	—	—	—	28	—	—	—
16	A	No	2	0	—	—	—	—	—	—	—	—	18	—	—	—
Totals		12	131	11	2	0	6	0	2	0	2	0	11	2	7	0
Below the range of Table 5 non-violent juveniles					<0.55 mg/dl^{-1}		<26 ng ml^{-1}		<3.0 μg ml^{-1}		<142 ng ml^{-1}		<29 ng ml^{-1}		<3.6 ng ml^{-1}	

A = active. P = placebo. — = normal.

here to a more generalized population without further study. Accordingly, the California legislature produced Section 1706 of the Health and Welfare Code to see if this study could be replicated with 402 incarcerated adult males, a group that better reflects a typical prison population. It also needs to be determined if such intervention can be successfully demonstrated under controlled conditions among parolees and probationers. The international war against violence demands no less of the medical and criminological research communities.

ACKNOWLEDGEMENTS

The authors would like to thank the Oklahoma Department of Health and Human Services, the Central Oklahoma Juvenile Treatment Facility, the Lloyd Rader Correctional Facility, the Wacker Foundation, Doctor's Data of Chicago, Act Laboratories, Klaire Laboratories, Dick Hanley, Steve Watson, Jack Campbell, Lilia Kirkpatrick, Bob Smith, Connelly Tunnel and the countless others who donated time and effort to test the hypotheses.

REFERENCES

[1] Schoenthaler S. Diet and crime: an empirical examination of the value of nutrition in the control and treatment of incarcerated juvenile offenders. Int J Biosocial Res 1983; 14: 25–39.
[2] Schoenthaler S. Diet and delinquency: a multi-state replication. Int J Biosocial Res 1983; 5: 70–8.
[3] Schoenthaler S. Nutritional policies and institutional antisocial behavior. Nutrition Today 1985; 20: 16–25.
[4] Schoenthaler S. Diet and delinquency: empirical testing of seven theories. Int J Biosocial Res 1986; 7: 108–31.
[5] Schoenthaler S. Malnutrition and maladaptive behavior. In: Essman W, ed. Nutrition and Brain Function. Basel, Switzerland: Karger Press, 1987; 198–218.
[6] Schoenthaler S, Moody J, Pankow L. Applied nutrition and behavior. J Appl Nutrition 1991; 43: 131–9.
[7] Whitney E, Sizer F. Nutrition Concepts and Controversies. New York: West Publishing, 1994.
[8] Essman W. (ed.). Nutrition and Brain Function. Basel, Switzerland: Karger Press, 1987.
[9] Crombie I, Todman J, McNeill G, et al. Effect of vitamin–mineral supplementation on verbal and non-verbal reasoning in schoolchildren. Lancet 1990; 335: 744–7.
[10] Farrington D, West D. Criminal, penal, and life histories of chronic offenders: risk and protection factors and early identification. Criminal Behav Ment Health 1994; 523–630.
[11] Wolfgang M, Figlio R, Sellin T. Delinquency in a Birth Cohort. Chicago: University of Chicago Press, 1972.
[12] Hamilton E, Whitney E, Sizer F. Instructor's Resource Manual: Nutrition Concepts and Controversy. New York: West Publishing, 1985.
[13] Simko M, Cowell C, Gilbride J. Nutritional Assessment. Rockville, MD: Aspen Systems, 1984.
[14] Prison Rule Violators. US Department of Justice, Office of Justice Programs, Bureau of Justice Statistics, Special Report, 1989.
[15] Federal Bureau of Investigations. Crime in the United States, 1992. Washington, DC: US Government Printing Office, 1993.
[16] National Research Council. National Survey Data on Food Consumption: Uses and Recommendations. Washington, DC: National Academy Press, 1984.
[17] Department of Health. The Diets of British Schoolchildren. London: HMSO, Report on Health and Social Subjects No. 36, 1989.
[18] Chandra R. Effects of vitamin and trace-element supplementation on immune responses and infection in elderly subjects. Lancet 1992; 340: 1124–27.
[19] Schoenthaler S, Amos S, Doraz W, et al. Controlled trial of vitamin–mineral supplementation on intelligence and brain function. Personal Indiv Diff 1991; 112: 343–50.