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Nutrient intakes, vitamin–mineral supplementation, and intelligence in British schoolchildren

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Children (227), aged 7–12 years, weighed and recorded all food and drink consumed for seven consecutive days. Each child completed tests of verbal and non-verbal intelligence, and was then randomly allocated to one of two groups after matching for age, sex, IQ and height. In a double-blind trial lasting for 28 d, one group received a vitamin–mineral supplement daily and the other group a placebo. On re-testing, there were no significant differences in performance between the two groups. Furthermore, there were no consistent correlations between test scores and micronutrient intakes based on the weighed records. Thus, we found no evidence that learning ability in a cross-section of British schoolchildren was limited by the quality of their diets.

Diet: Intelligence: Vitamin–mineral supplementation: Schoolchildren

Nutrient deficiencies, whether dietary or metabolic in origin, have long been known to cause learning disabilities and cognitive disorders (Passmore & Eastwood, 1986), and a number of studies have shown the benefits of dietary supplements on mental function in underfed children. It was reported, for example, that thiamin supplements improved test scores in 9- to 19-year-old children living in an orphanage in Virginia (Harrell, 1946). Pollitt *et al.* (1985) presented results on the positive effect of iron supplements on cognitive performance in Egyptian children with anaemia (mean age 9·5 years), while Walter *et al.* (1983) showed similar effects in infants aged 15 months in whom haemoglobin levels were normal but other biochemical indicators of Fe status were low. The benefits of a supplement (energy, protein, vitamins and minerals) on the cognitive competence of infants born into poverty in Bogota, Colombia were demonstrated by Waber *et al.* (1981), in a prospective study lasting 3·5 years. Likewise, Barrett & Frank (1987) showed that the provision of a broad-based supplement to Guatemalan children aged 6–8 years with mild to moderate protein–energy malnutrition resulted in improved mental test scores. In all these studies, however, evidence of undernutrition, obtained principally from anthropometric or biochemical measurements, was unequivocal. In the last two studies mentioned, the authors concluded that the effect of deprivation was to decrease motivation and arousal rather than to limit cognitive development *per se*, and that the benefits of supplementation diminish with increasing age.

A recent paper on the effect of vitamin and mineral supplementation in British schoolchildren purported to demonstrate that in 12- to 13-year-old children with apparently normal growth and no clinical signs of nutrient deficiency, additional vitamins and minerals had a positive effect on performance in tests of non-verbal intelligence (Benton & Roberts, 1988). This is a surprising and potentially important finding. While there is a significant proportion of British schoolchildren who fail to meet the recommended daily allowance (RDA) for one or more of the micronutrients (Department of Health and Social Security, 1979; Wenlock *et al.* 1986), it seems unlikely for a number of reasons, that marginal dietary deficiencies would affect brain function. Firstly, vitamins and minerals are known to be transported from the blood to the brain by specific active mechanisms that are saturable (Bradbury, 1979). Thus, micronutrient homeostasis occurs in the central nervous system. Second, the levels of micronutrient intake in British schoolchildren are, in the majority of cases, well above the RDA (Department of Health and Social Security, 1979; Wenlock *et al.* 1986). The one important exception is Fe, and concern has recently been expressed about the prevalence of anaemia in the adolescent population (Armstrong, 1989).

We have therefore undertaken a study to test the hypothesis that the diets of normal British schoolchildren are so lacking in micronutrients as to have an adverse effect on their mental performance. The effect of a balanced vitamin–mineral supplement on intelligence was determined in a double-blind trial; and the correlation was assessed between usual nutrient intake, measured using 7 d weighed records, and performance on intelligence tests.

METHODS

A total of 227 children were recruited through one primary school in Kent and two secondary schools in North London. Children in the primary school were randomly selected, and all selected children participated. In the secondary schools, the children were approached in their form groups by the fieldworkers, and those who wished to participate volunteered. There were twenty-five boys and twenty-six girls aged 7–10 years, and ninety-five boys and eighty-one girls aged 11–12 years.

The study was conducted between April and July 1988. The children first weighed and recorded all food and drink consumed for 7 d using Soehnle battery-operated digital scales. The parents of the primary schoolchildren attended training sessions given by the fieldworker at the school, while the older children received individual instruction in their form groups. All records were checked for completeness and accuracy after 24 h, after 3 d, and at the end of the week, and where necessary, parents were telephoned at home for clarification. Nutrient intakes were estimated using the Foodtabs program (T.A.B. Sanders, unpublished) which is based on tables from *McCance and Widdowson's The Composition of Foods* (Paul & Southgate, 1978) plus supplementary data (Wiles *et al.* 1980; Tan *et al.* 1985; unpublished results).

The children were then given tests of verbal and non-verbal intelligence. The younger children (7–10 years) completed the Heim AH1X test of non-verbal intelligence (Heim *et al.* 1977), while the older children (11–12) completed the Heim AH4 test of verbal and non-verbal intelligence (Heim *et al.* 1975). All children completed the WISC-R digit span and coding tests (Wechsler, 1976). The Heim tests were administered in groups, the WISC-R tests individually. Tests were administered by V.B., S.G. and N.G. who had been given training at the London Institute of Education.

Children were matched for age, sex, height (a crude index of pubertal development) and intelligence (on the basis of their non-verbal test scores), and randomized into two groups. In a double-blind trial lasting for 28 d, one group was given a vitamin–mineral supplement (see Table 1), the other a placebo which was identical in taste and appearance. The supplement was manufactured (Theravit Ltd, Belgium) to our own formulation and is not commercially available. Tablets were administered on weekdays by form teachers, and two additional tablets were given to each child to take at weekends. At the end of the trial, the younger children were given the Heim AH1Y test (a parallel test to the AH1X), the older children were given the AH4 test a second time, and all children repeated the digit span and coding tests. Children were asked not to take any other vitamin or mineral supplements during the intervention period.

Of the 227 children, 214 completed the full course of supplements and both sets of intelligence tests, 207 kept satisfactory diet records, and 194 completed all parts of the study successfully.

Ethical permission for the study was obtained from the King's College Human Experimentation Committee and, for the secondary schools, from the Barnett District Research Ethics Committee.

Statistical analysis. Results were analysed using the *Statistical Package for the Social Sciences* (SPSS, 1988). The effect of the supplement on intelligence was tested using analysis of variance, with age, sex and social class as covariates. The influence of diet on the first test scores was tested using multiple-regression analysis, again controlling for age, sex and social class.

RESULTS

Table 1 shows the composition of the vitamin–mineral supplement used in the present study compared with that of Benton & Roberts (1988). The amounts contained in our supplement were at or slightly above the UK RDA (Department of Health and Social Security, 1979), or at levels which would satisfy the known requirements of virtually all normal children in this age-group. Where the two supplements differ substantially, the Benton & Roberts (1988) supplement is either deficient in relation to known requirements (e.g. Fe, for which the RDA is 10–12 mg/d), or vastly in excess (e.g. ascorbic acid, for which the RDA is 20–30 mg/d). Our supplement contained selenium but not molybdenum whereas the other contained Mo but not Se. The Benton & Roberts (1988) supplement also contained bioflavinoids (50 mg), choline bitartrate (70 mg), inositol (30 mg), and *p*-aminobenzoic acid (10 mg); none of these is a vitamin for man.

The dietary intakes (means with SE) of the children are shown by sex and age group in Table 2, together with the percentage of the UK RDA. As expected, intakes of the boys were somewhat greater than those of girls for all nutrients, except for copper and vitamin C in the younger age group, and vitamins A, C and E amongst the older children. Average intakes were at or above the UK RDA for all nutrients except energy, Fe and vitamin D. These findings reflect those of the larger Department of Health and Social Security study (Wenlock *et al.* 1986), and the distributions of height and weight were also similar. The growth and diet of the children in the present study were thus characteristic of schoolchildren in the UK generally.

Children were randomly allocated to either the supplement group (S) or the placebo group (P), matching first by sex and exact age, and then by height and non-verbal test score. Table 3 gives means with SE for the presupplement values of height and non-verbal test score. There were no statistically significant differences between supplement and placebo group for any of the matching variables. Nutrient intake was determined subsequent to the matching. The greatest difference in nutrient intake between the supplement and placebo groups was for energy intake in girls aged 7–10 years (Table 3), but the difference did not reach statistical significance for energy, nor for any other nutrient in any of the age- or sex-groups.

Table 4 shows the means with SE of the intelligence test scores for the intervention groups (supplement or placebo) in two age-groups. (Results for boys and girls were combined as there were no differences in performance between sexes.) No significant differences in test scores were observed between intervention groups at the first test. As expected, the scores increased between the first and second tests. For none of the tests, however, was there a significantly greater increase in test scores in the supplement group compared with the placebo group. The greatest increase in test scores was seen amongst those children whose

Table 1. *Nutrient composition of the supplements used in the present study and in the study of Benton & Roberts (1988)*

Nutrient	Composition (per tablet)	
	Present study	Benton & Roberts (1988)
Calcium (mg)	100	100
Iron (mg)	15	1·3
Zinc (mg)	15	10
Chromium (μg)	200	200
Copper (mg)	2	–
Iodine (μg)	100	50
Magnesium (mg)	25	7·6
Manganese (mg)	1·5	1·5
Molybdenum (μg)	–	100
Selenium (μg)	150	–
Retinol equivalents (μg)	1000	375
Thiamin (mg)	2·2	3·9
Riboflavin (mg)	2·8	5
Nicotinic acid equivalents (mg)	24	50
Vitamin B_6 (mg)	2	12
Vitamin B_{12} (μg)	5	10
Folic acid (μg)	450	100
Biotin (μg)	100	100
Pantothenic acid (mg)	50	50
Ascorbic acid (mg)	50	500
Vitamin D (μg)	15	3
Vitamin E (mg)	10	70*
Vitamin K (μg)	100	100

* Given as IU.

initial test scores were in the bottom third of the distribution, but the increase in scores was the same whether they received supplement or placebo. A paired analysis gave the same result. These results indicate that the supplement had no effect on intelligence.

It might be suggested that the period of supplementation in our study was not long enough to produce an effect on test performance. We therefore compared the initial test scores of children who claimed to have taken vitamin–mineral supplements every week for more than 1 month in the year before the study, with the scores of those who did not take supplements. Seventy-one children took supplements, mainly vitamins A, C and D; four children took Fe tablets or tonic. The expectation was that those taking supplements would have higher initial test scores. However, there were no significant differences in initial test scores between the two groups (Table 5(*a*)). Another possibility was that those who had not taken supplements before the study would show a greater improvement in test score as a result of intervention with the vitamin–mineral supplement in our study. There was no such effect (Table 5(*b*)): the increase in test scores was the same in the supplement group and the placebo group regardless of whether or not children had taken supplements before the start of our study. There was, however, one statistically significant finding. Amongst the younger children, those who had taken supplements before our study showed a greater increase in non-verbal test scores than those who had not taken supplements. This was contrary to expectations.

Finally, in order to assess the possible influence of diet *per se* on intelligence, we examined the association between initial test scores and nutrient intake in the two age-groups. Multiple-regression analysis of initial test score *v*. nutrient intake, controlling for age, sex and social class, revealed a number of significant associations at $P < 0.05$.

Table 2. *Daily intakes of nutrients in 194 British boys and girls aged 7–12 years, and percentage of UK recommended daily amounts (RDA) (Department of Health and Social Security, 1979)*

(Mean values with their standard errors)

	Boys						Girls					
Age (years)...	7–10			11–12			7–10			11–12		
n...	25			76			26			67		
Nutrient	Mean	SE	% RDA	Mean	SE	% RDA	Mean	SE	% RDA	Mean	SE	% RDA
Energy: kJ	7594	285	85	7740	192	74	6916	272	83	7452	146	84
kcal	(1815)	(68)		(1850)	(46)		(1653)	(65)		(1781)	(35)	
Protein (g)	51·4	2·0	113*	60·8	1·6	131*	49·4	1·8	120*	57·2	1·6	128*
Fat (g)	73·7	2·8	–	77·3	2·2	–	64·8	3·3	–	76·3	1·9	–
% energy from fat	36·6	0·6	–	37·5	0·5	–	35·0	0·9	–	38·4	0·5	–
Carbohydrate (g)	252	11	–	243	7	–	233	10	–	230	5	–
Dietary fibre (g)	15·7	1·0	–	17·3	0·7	–	15·5	0·8	–	17·0	0·5	–
Calcium (mg)	726	31	112	768	26	110	649	33	100	701	28	100
Iron (mg)	9·1	0·4	83	11·2	0·5	93	9·2	0·7	83	10·0	0·3	84
Zinc (mg)	6·4	0·3	–	7·8	0·3	–	6·2	0·2	–	7·1	0·2	–
Copper (mg)	1·7	0·2	–	1·3	0·1	–	2·4	1·1	–	1·3	0·1	–
Retinol equivalents (μg)	661	92	140	685	91	105	565	132	112	718	108	108
Thiamin (mg)	1·15	0·06	136	1·21	0·05	119	1·16	0·08	145	1·04	0·04	120
Riboflavin (mg)	1·48	0·09	136	1·62	0·07	122	1·36	0·10	125	1·33	0·06	102
Nicotinic acid equivalents (mg)	23·7	1·0	191	28·0	0·9	184	22·9	1·0	184	25·2	0·7	164
Vitamin B_6 (mg)	1·1	0·1	–	1·3	0·05	–	1·1	0·1	–	1·2	0·04	–
Vitamin B_{12} (μg)	2·9	0·3	–	3·3	0·5	–	2·6	0·5	–	2·9	0·4	–
Folic acid (μg)	125	8·0	–	155	6·9	–	127	9·4	–	141	5·3	–
Biotin (μg)	14·9	0·9	–	15·8	0·7	–	12·1	0·8	–	13·7	0·6	–
Ascorbic acid (mg)	61·5	8·2	273	66·6	4·7	266	73·5	9·8	324	68·4	4·6	274
Vitamin D (μg)	1·66	0·16	67	1·74	0·22	70	1·34	0·19	54	1·5	0·10	60
Vitamin E (mg)	4·8	0·2	–	4·5	0·2	–	4·0	0·2	–	4·7	0·2	–

* RDA, 10% of energy as protein.

Table 3. *Presupplement values for height (m), non-verbal test score and energy intake (kJ/d) in matched groups receiving either the vitamin–mineral supplement (S)* or placebo (P)*

(Mean values with their standard errors)

		Boys				Girls			
Age (years)...		7–10		11–12		7–10		11–12	
n:	S...	12		45		13		37	
	P...	13		43		13		37	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Height (m):	S	1·32	0·020	1·48	0·012	1·33	0·017	1·52	0·011
	P	1·34	0·020	1·48	0·012	1·32	0·017	1·53	0·012
Non-verbal test score:	S	29·6	1·6	36·9	1·5	31·5	1·9	39·8	1·6
	P	28·8	2·0	36·1	1·5	30·2	1·6	38·8	1·7
Energy (kJ/d):	S	7343	347	7766	226	6510	385	7535	192
	P	7820	464	7711	305	7322	381	7368	222

* For details of composition, see Table 1.

Table 4. *Test scores for group tests (verbal and non-verbal) and individual tests (digit span and coding) taken before and after administration of vitamin–mineral supplement* or placebo in 210† British schoolchildren aged 7–12 years*

(Mean values with their standard errors)

Age (years)...	7–10						11–12					
	First test		Second test		Difference		First test		Second test		Difference	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Supplement												
n...			25						80			
Verbal	–		–		–		22·5	0·9	27·7	1·2	4·9	0·6
Non-verbal	30·6	1·3	34·2	1·6	3·6	0·9	38·2	1·1	45·8	1·2	7·5	0·9
Digit span	8·2	0·6	9·4	0·7	1·2	0·4	11·3	0·4	11·9	0·5	0·5	0·2
Coding	39·8	1·6	44·3	1·7	4·5	1·0	52·4	1·1	59·6	1·4	7·1	0·7
Placebo												
n...			25						80			
Verbal	–		–		–		21·5	0·9	27·6	1·0	6·1	0·5
Non-verbal	29·5	1·3	31·7	0·9	2·2	1·0	37·4	1·1	45·0	1·3	7·6	0·6
Digit span	8·7	0·4	9·1	0·4	0·4	0·4	10·8	0·3	11·7	0·3	0·9	0·2
Coding	38·7	1·2	43·6	1·3	4·8	1·1	50·7	1·1	57·4	1·3	6·8	0·8

* For details of composition, see Table 1.

† Four children who completed the course of supplements or placebos failed to complete all tests on both occasions.

However, none of the associations was present in both age-groups, and with one exception, none was related to micronutrients nor explained more than 5% of the variance in the test scores. For example, amongst the older (but not the younger) children, the percentage of energy derived from sugar was positively associated with the non-verbal test scores (b 0·36, $P = 0{\cdot}0237$, r^2 0·03), whereas the percentage of energy derived from saturated fatty acids

Table 5. *Effect of vitamin – mineral supplements taken before the study on* (a) *initial test scores, and* (b) *change in test scores according to study intervention group* (*supplement* (*S*)†, *placebo* (*P*)) *in 203 British schoolchildren aged 7–12 years*

(Mean values with their standard errors)

Age (years)...		7–10				11–12			
Dietary supplements...		Yes		No		Yes		No	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
(*a*) Initial test score									
n		23		28		48		104	
Verbal		–		–	–	22·1	1·0	22·1	0·9
Non-verbal		28·7	1·4	31·1	1·2	40·4	1·4	36·9	1·0
Digit span		8·4	0·5	8·5	0·5	11·4	0·4	11·1	0·3
Coding		38·6	1·5	39·8	1·4	54·6	1·4	50·7	1·0
(*b*) Change in test score									
n	S	13		12		27		47	
	P	9		16		20		55	
Verbal:	S	–	–	–	–	6·4	1·0	4·4	0·8
	P	–	–	–	–	7·4	0·8	5·6	0·6
Non-verbal:	S	5·4	1·3	1·8	1·1	7·5	1·1	7·0	1·4
	P	3·9	1·6	1·0*	1·3	9·0	1·5	7·8	0·7
Digit span:	S	1·3	0·6	1·1	0·6	0·4	0·4	0·4	0·3
	P	1·6	0·6	−0·2	0·4	1·1	0·4	0·8	0·3
Coding:	S	3·5	1·5	5·7	1·4	7·7	1·1	7·2	0·9
	P	4·7	2·2	4·8	1·3	7·4	1·6	6·3	0·9

* Difference between mean for the group taking supplements before the study and mean for those not taking supplements was significant (two factor analysis of variance): $P = 0{\cdot}023$.

† For details of composition, see Table 1.

was negatively associated (b $-0{\cdot}81$, $P = 0{\cdot}0123$, r^2 0·04). Polyunsaturated fatty acid intake was negatively associated with the digit span score (b $-0{\cdot}23$, $P = 0{\cdot}0141$, r^2 0·03). Only one statistically significant association between the intake of any vitamin or mineral and any of the test scores was demonstrated. Amongst the younger children, vitamin C intake was positively associated with the coding score (b 0·06, $P = 0{\cdot}003$, r^2 0·17).

DISCUSSION

Results from our intervention study show clearly that no improvement in intelligence can be expected from the administration of vitamin–mineral supplements over 28 d to typical British schoolchildren.

The social class distributions of the schoolchildren reflected that of the populations of the electoral wards in which the schools were located, and included a substantial proportion of children from social classes IV and V. The distributions of height and weight were similar to those reported by the Department of Health and Social Security (Wenlock *et al.* 1986), as were the diets of the older children in the study. It is likely, therefore, that the samples were representative of the general population of British schoolchildren.

For those nutrients for which an RDA has been established in the UK, intakes were less than 100% only for energy, Fe and vitamin D (Table 2). Intakes of energy in the UK, however, have been falling in parallel with reduced activity levels for several decades. Low Fe intakes are of concern (Addy, 1986), and a recent report on the Fe status of Irish adolescents has shown that 13% of males and 7% of females aged 14–18 years have low haemoglobin levels (< 130 and < 120 g/l respectively), and as high as 40% have ferritin levels below 10 μg/l (Armstrong, 1989). No biochemical measures of Fe status were made in the present study, but the range of Fe intakes (4·0–25·3 mg/d) should have been sufficient to test hypotheses regarding intelligence and Fe status. Low vitamin D intake is of concern only amongst the populations with limited exposure to sunlight. Given that physical education involving outdoor activities is a normal part of the school curriculum, it is unlikely that pupils would have had inadequate tissue levels of vitamin D.

Any deficiencies of micronutrients which may have existed within the study sample would have been rapidly corrected by the daily provision of the supplement listed in Table 1. If the test performances of the children were in any way related to functional impairment caused by local nutrient deficiencies, 28 d of supplementation would have been more than adequate to permit such deficiencies to be rectified. The one exception is Fe, for which a supplementary period of at least 90 d would be required for the full effect of Fe on haemoglobin status to be revealed. However, in the study by Walter *et al.* (1983), a positive effect of Fe supplementation on mental development scores was observed in anaemic infants within 10 d, suggesting that 'iron lack not anaemia was the determinant for the response to iron therapy'.

The tests used in the present study were designed to assess a range of mental function. The Heim tests stress deductive reasoning, the emphasis being on verbal and numerical skills in the 'verbal' test and diagrammatic skills in the 'non-verbal' test. The digit span test emphasizes short-term memory, attention and concentration, whereas the coding test stresses speed of learning, motivation and accuracy of hand–eye co-ordination as well as short-term memory and attention (Sattler, 1982). These tests therefore assess a broad range of mental functioning and ability, from skills based on cumulative learning to those which are, in theory, primarily biochemical in nature. We were advised against giving verbal tests to the younger children because of questions concerning their reliability.

Our findings on the effects of a vitamin–mineral supplement do not support those of Benton & Roberts (1988). Although they reported very low nutrient intakes, particularly of Fe, it is likely that the nutrient intakes were substantially underestimated (Emery *et al.* 1988). Moreover, the daily supplement they used provided 1·3 mg Fe only so the effects reported could not have been due to increased Fe intakes. Benton & Roberts (1988) and Benton (1988*a*, *b*) have also been unable to account for the anomalous finding that the placebo group failed to increase their non-verbal scores on re-testing some 8 months later, when one would have expected a learning effect to result in increased scores on retesting, and it is this anomaly that is central to their conclusion that supplementation improves non-verbal intelligence. Evidence that an *untreated* group improved their non-verbal test scores further weakens their conclusion.

In the present study, over a wide range of children's abilities, developmental stages, and diets, we have failed to demonstrate that either pre-existing diet or vitamin and mineral supplementation of the diet has an influence on mental performance. When we examined the influence of reported vitamin and mineral supplementation in the year before our study (Table 5), we found only one statistically significant association showing, in the younger age-group only, a greater improvement in test scores in the children taking supplements compared with those not taking supplements. This difference, which is contrary to expectations, was probably due to a regression to the mean effect. The average initial test score of the group taking supplements before the study was slightly lower than that of the group taking no supplements (28·7 *v.* 31·1, again contrary to expectations), but the final test scores of the two groups were not significantly different (33·2 *v.* 32·4). There is, thus, no evidence to suggest that taking supplements during the year before the study in any way influenced the outcome of the tests.

When we examined the influence of present diet on test performance, we found only one significant correlation between vitamin or mineral intake and test performance, a positive association of vitamin C intake and coding scores amongst the younger children. This was probably a statistical artefact. When the two children with exceptionally large vitamin C intakes were excluded, the value for P rose from 0·003 to 0·03, and r^2 fell from 0·17 to 0·09. Given the number of regression analyses that were completed, it is highly probable that at least one association at this level of significance would have arisen by chance. One cannot conclude that higher intakes of vitamin C result in higher coding test scores in the general population of young schoolchildren. The lack of association of vitamin C with any of the other non-verbal test results, and the failure to show an association of vitamin C and coding score in the older children lends support to the interpretation that the observed association is likely to be a statistical artefact. Although a previous study suggested a positive relationship between vitamin C status (assessed by leucocyte ascorbic acid levels) and intellectual performance (Kubala & Katz, 1960), it failed to take into account the possible association of high leucocyte ascorbic acid levels with a home environment in which there was a greater pressure to perform better academically. Moreover, their intervention trial was not double blind, and there is considerable evidence to show that involvement in refeeding programmes has beneficial effects on behaviour and mental performance independent of the nutritional intervention (Barrett & Frank, 1987). Benton (1981) has suggested that a single large dose of vitamin C (1–2 g) actually impairs psychological functions (poorer reaction times and psychomotor co-ordination) in young adults.

We must therefore conclude that the variation in nutrient intake amongst average British schoolchildren is a very minor determinant of mental functioning. It seems highly unlikely that the consumption of vitamin and mineral supplements by the average British child will have any appreciable effects on intelligence. This is not to say that there may be some British children who are disadvantaged in relation to diet or health (Nelson & Naismith, 1979) for whom the addition of a supplement would not be of benefit. (Such a supplement might usefully contain energy as well as vitamins and minerals.) But even in these cases, it is not clear that the influence of a supplement would be on intelligence *per se*. Rather, improvements in motivation, attention, and concentration might allow gains in performance on tests of intelligence.

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