

Dietary Supplements and Intelligence /Academic Performance

Benton D. Micro-nutrient supplementation and the intelligence of children.

Neurosci Biobehav Rev 2001 Jun;25(4):297-309.

A growing number of double-blind placebo-controlled studies have considered the influence of micro-nutrient supplementation on the intelligence of children. Earlier studies prevented the drawing of conclusions as they did not systematically approach the topic. However, over the last 10 years, a series of studies have compared the impact of supplementation on either verbal or non-verbal measures of intelligence. In 10 out of 13 studies a positive response has been reported, always with non-verbal measures, in at least a sub-section of the experimental sample. A selective response to non-verbal tests was predicted as they reflect basic biologically functioning that could be expected to be influenced by diet. The evidence is that not all children respond to supplementation, rather there is a minority who benefit, whose diet offers low amounts of micro-nutrients. Such observations are consistent with dietary surveys that typically report a sub-set of children with a low intake. The topic is at a very early stage and needs the clarification gained from a series of large-scale studies that consider children of a wide range of ages, dietary styles and social backgrounds.

Benton, D. "Vitamin and mineral intake and human behaviour." In: Smith, Andrew P. (Ed); Jones, Dylan M. (Ed). (1992). Handbook of human performance, Vol. 1: The physical environment; Vol. 2: Health and performance; Vol. 3: State and trait. (pp. 25-47). San Diego, CA, US: Academic Press, Inc. 1117 pp. ISBN 0-12-650354-0.

(from the chapter) [examines] the association between the intake of vitamins and minerals and psychological functioning / [argues] that there is a growing evidence to support the assertion that, for some of the population, a sub-clinical deficiency of micro-nutrients exists to the extent that psychological efficiency is disrupted / [reviews] the psychological concomitants of clinical and experimentally-induced deficiencies multi-vitamin and mineral supplementation [supplementation of children, evaluation studies examining supplementation and intelligence, supplementation and the behavioural problems of children] / vitamin status and adult behaviour [the elderly, mood] (PsycINFO Database Record (c) 2000 APA, all rights reserved) Form/Content Type Literature Review/Research Review.

Benton, David. Vitamin/mineral supplementation and the intelligence of children: A review.

Journal of Orthomolecular Medicine. Vol 7(1) 1992, 31-38.

Reviews 7 studies that examined the impact of vitamin/mineral supplementation on children's performance on intelligence tests. Five studies reported that the taking of supplements was associated with improved nonverbal performance, especially in children whose diets were low in vitamins and minerals. Supplementation may be associated with improved mood and ability to sustain attention, although it is unclear whether these factors completely account for improved performance. (PsycINFO Database Record (c) 2000 APA, all rights reserved).

Benton D, Buts JP. Vitamin/mineral supplementation and intelligence. Lancet 1990 May 12;335(8698):1158-60 Comment on: Lancet. 1990 Mar 31;335(8692):744-7. Publication Types: Clinical trial. Comment Controlled clinical trial. Letter.

Comment in: Lancet. 1990 Jul 21;336(8708):175-6

Benton, David, Cook, Richard. Vitamin and mineral supplements improve the intelligence scores and concentration of six-year-old children. Personality & Individual Differences. Vol 12(11), 1991, 1151-1158.

47 6-yr-old children, under a double-blind procedure, took either a placebo or a tablet containing 23 vitamins and minerals at 50, 100, or 200% of the US recommended daily allowance. Before taking the tablets, and after 6 wks in one school and 8 wks in another, the Ss took 4 subscales of the British Ability Scales and a delayed reaction time (RT) task. The intelligence scores of Ss taking the active tablets increased while the scores of Ss taking the placebo declined, primarily on nonverbal rather than verbal measures. When faced with a difficult task, Ss were more likely to concentrate having taken the active supplement. There was a significant relationship between the amount of sugar consumed in the diet and the improvement in intelligence scores when taking the vitamin/mineral supplement. (PsycINFO Database Record (c) 2000 APA, all rights reserved) Form/Content Type Empirical Study.

Benton D, Roberts G. Effect of vitamin and mineral supplementation on intelligence of a sample of schoolchildren. Lancet 1988 Jan 23;1(8578):140-3

90 schoolchildren aged twelve and thirteen years kept a dietary diary for three days. In most cases the average intake of vitamins was close to the recommended daily allowance, although for a minority the intake was low; with minerals the recommended daily allowance was less commonly achieved. To examine the possibility that deficiency of dietary minerals and vitamins was preventing optimum psychological function, a multivitamin/mineral supplement or a placebo was administered double-blind for eight months to 60 of the children. The supplement group, but not the placebo group or the remaining 30 who took no tablets, showed a significant increase in non-verbal intelligence. Publication Types: Clinical trial Randomized controlled trial.

Boggs, Unabelle R, Scheaf, Allen, Santoro, David, Ritzman, Robert. The effect of nutrient supplements on the biological and psychological characteristics of low IQ, preschool children. Journal of Orthomolecular Psychiatry. Vol 14(2), 1985, 97-127.

Studied whether measures of developmental impairment or behavioral disorders could be improved by the use of multinutritional supplements individually prescribed to 9 preschool children enrolled in Headstart programs. Ss had a high degree of developmental risk and a Slossen Intelligence Test IQ below 80. After being administered a battery of physiological and psychological tests, half the Ss received nutrient supplements in powdered form and the other half received placebo for 1 mo. During the 2nd half of the experiment, conditions for Ss were reversed. Six Ss remained in full participation throughout the study. An analysis of variance (ANOVA) showed that of the nutrients administered, zinc was the only one that was proven to have been deficient and beneficial. However, overall the supplements had a beneficial effect on the behavioral disturbance and intellectual development of Ss. (112 ref) (PsycINFO Database Record (c) 2000 APA, all rights reserved). Form/Content Type Empirical Study.

Boivin MJ, Giordani B. Improvements in cognitive performance for schoolchildren in Zaire, Africa, following an iron supplement and treatment for intestinal parasites. J-Pediatr-Psychol. 1993 Apr; 18(2): 249-64.

Abstract: Tested 47 first-year primary school children at a mission school in rural Zaire for cognitive ability with the Kaufman Assessment Battery for Children (K-ABC) adopted to the language of Kituba. Within a day of this test, each child was evaluated for blood hemoglobin (Hgb) level and the presence of intestinal parasites. Half of the children received an iron supplement (20 mg Fe) for 30 days and those children positive for the intestinal parasites of ankylostome or ascaris were randomly selected to receive either a vermifuge treatment or placebo. All of the children were again evaluated medically and cognitively 4 weeks after the initiation of treatment. Using discriminant analysis, performance on the Mental Processing Composite of the K-ABC 1 month after treatment in combination with increases in blood Hgb resulted in the successful classification of 74% in terms whether a child had received both iron supplement and vermifuge treatment ($p = .007$). With respect to our home evaluation for each

child, factors related to the nutritional and economic well-being of the home environment proved a reliable marker for Simultaneous Processing ability. However, the present findings also suggest that over the short-term, changes in blood Hgb that accompany both vermifuge and iron supplement treatment together can improve certain aspects of cognitive ability, perhaps by means of heightened attentional capacity.

Carlton RM, Ente G, Blum L, Heyman N, Davis W, Ambrosino S. Rational dosages of nutrients have a prolonged effect on learning disabilities. *Altern Ther Health Med* 2000 May;6(3):85-91

CONTEXT: Reports that administration of nutrients has increased the academic performance of learning-disabled children exist in the literature. **OBJECTIVE:** To document the effects of nutrients on learning-disabled children in a controlled study. **DESIGN:** A randomized, double-blind, placebo-controlled crossover trial, which followed 1 year of open-label nutrients. Children who improved in the open-label trial were eligible to enter the controlled phase of the study. **SETTING:** Subjects were enrolled from the general community through advertisements. **PATIENTS OR OTHER PARTICIPANTS:** Twenty children met the criteria for being learning disabled. **INTERVENTION:** Each child was tried out on some (but not necessarily all) of the B vitamins and minerals used in this study. These were administered semi-blinded for the first year; double-blinded in crossover rotations during the second year; and open-label in the ensuing years. **MAIN OUTCOME MEASURES:** At various time points, school-certified psychologists administered psychoeducational tests. School report cards were evaluated at baseline and for all subsequent periods. **RESULTS:** Twenty learning-disabled children entered the study, but 1 dropped out because of nausea. The remaining 19 children showed significant academic and behavioral improvements within a few weeks or months of open-label treatment with nutrient supplements. Some children gained 3 to 5 years in reading comprehension within the first year of treatment; and all children in special education classes became mainstreamed, and their grades rose significantly. Twelve of the children completed the 1-year double-blind phase, after which approximately half of the children chose to remain on the nutrients for at least 2 additional years. For those who discontinued, it took at least 1 year to begin to see the first indications of decline in academic performance, and another year for their grades to drop significantly. In contrast, for children who remained on nutrients, the gains continued the upward trend; at the end of year 4, the difference in scores between the 2 groups had reached statistical significance ($P < .01$). **CONCLUSION:** The overall results of this study tentatively support the concept that learning disabilities may in some cases be a nutrient-responsive disorder. **Publication Types:** Clinical trial
Randomized controlled trial.

Carroll, H. C. M. A psychometric critique of Nelson et al.'s 1990 paper: Nutrient intakes, vitamin-mineral supplementation and intelligence in British schoolchildren. *Personality & Individual Differences*. Vol 18(5), May1995, 669-675.

Critiques the work of M. Nelson et al (1990) on nutrient intakes, vitamin-mineral supplementation, and intelligence in British schoolchildren. The measures of intelligence employed had questionable validity and reliability. The use of a matched pairs design was weak, and ANOVA failed to take into account regression in the analysis of the psychometric data. It is concluded that Nelson and colleagues were not justified in coming to a conclusion about the effect of diet on intelligence. (PscINFO Database Record (c) 2000 APA, all rights reserved)
Form/Content Type Comment.

Crombie IK, Todman J, McNeill G, Florey CD, Menzies I, Kennedy RA. Effect of vitamin and mineral supplementation on verbal and non-verbal reasoning of schoolchildren. *Lancet* 1990 Mar 31;335(8692):744-7

Comment in: *Lancet*. 1990 May 12;335(8698):1158-60

In a randomised controlled trial the effect of vitamin and mineral supplementation for seven months on performance in tests of reasoning was studied in 86 schoolchildren aged 11-13. A small, non-significant difference between the control and supplementation groups was found in a non-verbal test. The net difference in change in scores between the active and placebo groups was 2.4 units (95% CI-1.5 to 6.3). This direction of effect was not consistently seen with three other tests of non-verbal reasoning. Vitamin and mineral supplementation does not improve the performance of schoolchildren in tests of reasoning. Publication Types: Clinical trial Randomized controlled trial.

Crombie IK, Todman J, McNeill G, Florey CD. Vitamin/mineral supplementation and intelligence. Lancet 1990 Jul 21;336(8708):175-6

Comment on: Lancet. 1990 May 12;335(8698):1158-60
Publication Types: Comment Letter

Emery PW. Vitamin/mineral supplementation and non-verbal intelligence Lancet 1988 Feb 20;1(8582):407-9.

Eysenck, Hans J. Raising I.Q. through vitamin and mineral supplementation: An introduction. Personality & Individual Differences. Vol 12(4), , England: Elsevier Science Ltd.. 1991, 329-333.

Reviews studies that lend support to the hypothesis that many children in the US and the UK suffer from vitamin and mineral deficiencies that keep their IQs below optimum level. It is argued that suitable supplementation can help them approach that level more closely. Age-related questions and social and scientific consequences raised by these findings are discussed. (PsycINFO Database Record (c) 2000 APA, all rights reserved).

Eysenck, H. J; Schoenthaler, S. J. "Raising IQ level by vitamin and mineral supplementation." In: Sternberg, Robert J. (Ed); Grigorenko, Elena L. (Ed). (1997). Intelligence, heredity, and environment. (pp. 363-392). New York, NY, US; New York, NY, US: Cambridge University Press; xvii, 608 pp. ISBN 0-521-46489-7.

(from the chapter) Vitamin and mineral intake clearly is essentially an environmental determinant, so that if we equated such intake, roughly at least, for all children, the importance of genetic factors would increase. This chapter starts with the points: (1) vitamins and minerals are essential for proper (optimal) mental functioning, and (2) there are great individual differences in the intake and metabolism of such micronutrients. Explores the possibility that IQ can be raised through vitamin and mineral supplementation. Themes discussed in this chapter are as follows: theory and paradigm; nutrition and nonverbal intelligence and blood analysis. (PsycINFO Database Record (c) 2000 APA, all rights reserved). Publication Type Chapter.

Grantham McGregor SM, Walker SP, Chang SM, Powell CA. Effects of early childhood supplementation with and without stimulation on later development in stunted Jamaican children. Am-J-Clin-Nutr. 1997 Aug; 66(2): 247-53.

Abstract: It is not known whether nutritional supplementation in early childhood has long-term benefits on stunted children's mental development. We followed up 127 7-8-y old children who had been stunted in early childhood and received supplementation, stimulation, or both. At 9-24 mo of age, the children had been randomly assigned to four treatment groups: nutritional supplementation, stimulation, both treatments, and control. After 2 y, supplementation and stimulation had independent benefits on the children's development and the effects were additive. The group receiving both treatments caught up to a matched group of 32 nonstunted children. Four years after the end of the 2-y intervention 97% of the children were given a battery of cognitive function, school achievement, and fine motor tests. An additional 52 nonstunted

children were included. Factor analyses of the test scores produced three factors: general cognitive, perceptual-motor, and memory. One, the perceptual-motor factor, showed a significant benefit from stimulation, and supplementation benefited only those children whose mothers had higher verbal intelligence quotients. However, each intervention group had higher scores than the control subjects on more tests than would be expected by chance (supplemented and both groups on 14 of 15 tests, $P = 0.002$; stimulated group in 13 of 15 tests, $P = 0.01$), suggesting a very small global benefit. There was no longer an additive effect of combined treatments at the end of the intervention. The stunted control group had significantly lower scores than the nonstunted children on most tests. Stunted children's heights and head circumferences on enrollment significantly predicted intelligence quotient at follow-up.

Lozoff B, Jimenez E, Wolf AW. Long-term developmental outcome of infants with iron deficiency. *N-Engl-J-Med.* 1991 Sep 5; 325(10): 687-94.

Abstract: **BACKGROUND.** Iron-deficiency anemia has been associated with lowered scores on tests of mental and motor development in infancy. However, the long-term developmental outcome of infants with iron deficiency is unknown, because developmental tests in infancy do not predict later intellectual functioning. **METHODS.** This study is a follow-up evaluation of a group of Costa Rican children whose iron status and treatment were documented in infancy. Eighty-five percent (163) of the 191 children in the original group underwent comprehensive clinical, nutritional, and psychoeducational assessments at five years of age. The developmental test battery consisted of the Wechsler Preschool and Primary Scale of Intelligence, the Spanish version of the Woodcock-Johnson Psycho-Educational Battery, the Beery Developmental Test of Visual-Motor Integration, the Goodenough-Harris Draw-a-Man Test, and the Bruininks-Oseretsky Test of Motor Proficiency. **RESULTS.** All the children had excellent hematologic status and growth at five years of age. However, children who had moderately severe iron-deficiency anemia as infants, with hemoglobin levels less than or equal to 100 g per liter, had lower scores on tests of mental and motor functioning at school entry than the rest of the children. Although these children also came from less socioeconomically advantaged homes, their test scores remained significantly lower than those of the other children after we controlled for a comprehensive set of background factors. For example, the mean (\pm SD) adjusted Woodcock-Johnson preschool cluster score for the children who had moderate anemia in infancy ($n = 30$) was 448.6 ± 9.7 , as compared with 452.9 ± 9.2 for the rest of the children ($n = 133$) (P less than 0.01); the adjusted visual-motor integration score was 5.9 ± 2.1 , as compared with 6.7 ± 2.3 (P less than 0.05). **CONCLUSIONS.** Children who have iron-deficiency anemia in infancy are at risk for long-lasting developmental disadvantage as compared with their peers with better iron status.

Naismith DJ, Nelson M, Burley VJ, Gatenby SJ. Can children's intelligence be increased by vitamin and mineral supplements? *Lancet* 1988 Aug 6;2(8606):335.

This refers to the study of school children in North Wales, whose intelligence was claimed to have risen considerably after an 8-month dose of multi vitamins and minerals. This study was reported earlier this year in the *Lancet*. The authors refute the findings, criticizing its poor methodology and statistical treatment, and cite their own replicating study in two contrasting schools using a much larger sample. Initial findings show that such supplementation will benefit those children on a poor diet, but it is unlikely that any improvement in intellectual performance will be proven. Results of the diet analysis will be reported later.

Nelson M. Vitamin and mineral supplementation and academic performance in schoolchildren. *Proc Nutr Soc* 1992 Dec;51(3):303-13

Publication Types: Review Review, tutorial

Nelson M, Naismith DJ, Burley V, Gatenby S, Geddes N. Nutrient intakes, vitamin-mineral supplementation, and intelligence in British schoolchildren. *Br J Nutr* 1990 Jul;64(1):13-22
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 was 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.
Publication Types: Clinical trial Randomized controlled trial

O'Dea J. Rawstone P. Consumption of dietary supplements and energy drinks by schoolchildren. *Medical Journal of Australia* 2000 Oct 2;173(7):389.

Pagliari, H. Claudia. Effects of nutritional supplements on intelligence: Comment on Schoenthaler et al.'s paper. *Personality & Individual Differences*. Vol 14(3), Mar. 1993, 493.
Reexamined data from a study by S. J. Schoenthaler et al (see record 1991-25380-001). Large discrepancies between reported mean test scores and established norms are pointed out, as is a source of error in the calculations of intellectual improvements following supplementation. (PsycINFO Database Record (c) 2000 APA, all rights reserved) (unassigned)
Form/Content Type Comment.

Pollitt, E. Iron deficiency and educational deficiency. *Nutrition-reviews*. Apr 1997. v. 55(4) p. 133-141.

Abstract: Existing data suggest that iron deficiency anemia (IDA) is a risk factor for poor educational performance in schoolchildren. The synergistic effect of IDA in combination with other forms of malnutrition and other risk factors may affect educational performance more strongly. Thus, IDA and its effect on educational performance should be studied in the context of other risk factors.

Peritz E. The Turlock vitamin-mineral supplementation trial: a statistical reanalysis. *J Biosoc Sci* 1994 Apr;26(2):155-64

A new analysis of a randomised double-blind trial confirms the fact that vitamin-mineral supplementation has a statistically significant effect on non-verbal IQ as measured by the WISC-R test. Further studies may show if this effect is large enough to be of practical importance.

Pollitt E Gorman KS Engle PL Rivera JA Martorell R . Nutrition in early life and the fulfillment of intellectual potential. *J-Nutr*. 1995 Apr; 125(4 Suppl): 1111S-1118S 1995
The effects of early supplementary feeding on cognition are investigated using data collected during two periods in four Guatemalan villages. The first was the Institute of Nutrition of Central America and Panama (INCAP) longitudinal study from 1969 to 1977 and the second was a cross-sectional follow-up of former participants carried out in 1988-1989. The principal objective of these studies was to assess the differential effect of two dietary supplements, Atole containing 163 kcal/682 kJ and 11.5 g protein per cup or 180 mL and Fresco containing 59 kcal/247 kJ and 0 g protein per cup, that were given to mothers, infants and young children. Performance was assessed on a battery of psychoeducational and information processing tests that were administered during adolescence. Consistent differences between groups were observed on psychoeducational tests. Subjects receiving Atole scored significantly higher on tests of knowledge, numeracy, reading and vocabulary than those given Fresco. Atole ingestion also was associated with faster reaction time in information processing tasks. In addition, there were

significant interactions between type of dietary supplement and socioeconomic status (SES) of subjects. In Atole villages, there were no differences in performance between subjects in the lowest and highest SES categories. On the other hand, performance in Fresco villages was best in the highest compared with the lowest SES group. After close scrutiny of alternative hypotheses, it is concluded that dietary changes produced by supplementation provide the strongest explanation for the test performance differences observed in the follow-up between subjects exposed to Atole and those exposed to Fresco supplementation.

Pollitt E Watkins WE Husaini MA. Three-month nutritional supplementation in Indonesian infants and toddlers benefits memory function 8 y later. *Am-J-Clin-Nutr.* 1997 Dec; 66(6): 1357-63 1997.

Does short-term supplementary feeding during infancy and childhood have long-lasting effects? In 1986, 334 children aged 6-60 mo living on rural tea plantations in West Java, Indonesia, participated in a 3-mo randomized trial to test the effects of a dietary supplement providing approximately 1672 kJ (400 kcal) energy/d, with about the same nutrient density as local foods. We returned to the same communities in 1994 and enrolled 231 (125 supplemented, 106 control) of the original subjects in a follow-up study of the long-term effects of supplementation. We assessed these subjects by using several measures: anthropometry, iron status, information processing, Peabody Picture Vocabulary Test, word fluency, and an arithmetic test. The supplemented group showed no differences from those in the control group. However, when the analysis was limited to subjects who had received the supplement before the age of 18 mo (n = 73), the supplemented children performed better than control children on the Sternberg test of working memory (decision time intercept: probe absent, P = 0.002; probe present, P = 0.053). After considering possible confounders, we concluded that the supplementation during infancy was responsible for the difference. This finding shows that supplementation can have long-lasting effects on a specific domain if the child receives it at the appropriate stage of development.

Ricciuti, Henry N. Nutrition and mental development. *Current Directions in Psychological Science.* Vol 2(2) Apr 1993, 43-46.

Discusses behavioral and biomedical research conducted over the past 30 years on the relationship between nutrition and cognitive/behavioral development, particularly intellectual competence. The effects on the brain development of nutritional deficiency and vitamin/mineral supplements have also been studied. Recent research in protein-energy malnutrition, developmental environment, iron deficiency, and mineral and vitamin supplements for child mental development in low-income families is reviewed. It is suggested that prevention must encompass both health and developmental environments of children at risk, rather than only their nutritional or dietary needs. (PsycINFO Database Record (c) 2000 APA, all rights reserved).

Rippere V. Benton D. Vitamins, minerals and IQ. *Lancet* 1988 Sep 24;2(8613):744-5.

These letters are in reply to Professor Naismith's article (Aug 6, 335) refuting the claim by D. Benton that vitamin and mineral supplementation can enhance a child's IQ. Dr Rippere points out Naismith's findings contradict those of the last fifty years, citing the studies, and highlights the discrepancies in his study, claiming to replicate Benton's work. These discrepancies are confirmed in Benton's reply.

Roberts G. Boost your child's brain power: how to use good nutrition to ensure success at school. Wellingborough: Thorsons, 1988. 142pp. ISBN: 0-7225-1752-1 Wellingborough: Thorsons, 1988. 142pp. ISBN: 0-7225-1752-1.

By the author of the study of vitamin/mineral supplementation on children in the North Wales school where he was headmaster. The study found such supplementation greatly improved the children's IQ.

Schoenthaler, S. J. Effects of nutritional supplements on intelligence: Comment on Schoenthaler et al.'s paper: Response. *Personality & Individual Differences*. Vol 14(3), Mar 1993, 493.

Responses to the comments by H. C. Pagliari (see record 1993-38578-001) concerning the low Raven's Matrices scores and incorrect SD scores of the Wechsler Intelligence Scale for Children--Revised (WISC--R) published by the author. The author agrees that the scores were low and that the SD scores were incorrect; however, this does not alter the fact that proper measures of variation were used. (PsycINFO Database Record (c) 2000 APA, all rights reserved) (unassigned) Key Phrase Identifiers vitamin & mineral supplementation, intelligence & performance, 12-16 yr olds, commentary reply.

Schoenthaler, Stephen J; Amos, Stephen P; Doraz, Walter E; Kelly, Mary A; et al. Controlled trial of vitamin-mineral supplementation on intelligence and brain function.

Personality & Individual Differences. Vol 12(4), 1991, 343-350.

Administered vitamin-mineral supplements (SUP) to 15 juvenile delinquents and placebo to 11 juvenile delinquent controls (CTLs). Ss were 13-16 yrs old. After 13 wks, SUP Ss produced significantly larger gains in nonverbal IQ. Ss who showed an improvement in blood nutrient concentrations had a significantly greater increase in IQ scores than Ss whose blood concentrations were unchanged. EEG mappings on 4 SUP Ss whose nutrient concentrations had become normal and on 2 CTLs whose nutrient concentrations remained low revealed that SUP Ss showed a reduction in brain wave abnormalities from 14 to 2. (PsycINFO Database Record (c) 2000 APA, all rights reserved) Form/Content Type Empirical Study; Treatment Outcome Study; Clinical Trial.

Schoenthaler, Stephen J; Amos, Stephen P; Eysenck, Hans J; Peritz, E; et al. Controlled trial of vitamin-mineral supplementation: Effects on intelligence and performance.

Personality & Individual Differences. Vol 12(4), 1991, 351-362.

Administered 3 different strengths of vitamin-mineral supplements or placebo to 615 school children (aged 12-16 yrs) who were pre- and posttested on intelligence measures. On nonverbal Wechsler Intelligence Scale for Children (WISC) tests, Ss who received supplements exhibited highly significant improvements in IQ, whereas for the verbal tests there were none. Findings support the hypothesis that fluid intelligence, as measured by the nonverbal test, might be improved by supplementation, whereas crystallized ability tests (verbal tests) would be unlikely to be so improved. Other tests, including Progressive Matrices, the Comprehensive Test of Basic Skills, the Matrix Analogies Test, and measures of reaction time (RT) and inspection time, support the contribution that vitamin and mineral supplementation can make to the improvement of IQ. (PsycINFO Database Record (c) 2000 APA, all rights reserved) Form/Content Type Empirical Study; Treatment Outcome Study; Clinical Trial.

Schoenthaler SJ. Bier ID. Young K. Nichols D. Janssens S.

The effect of vitamin-mineral supplementation on the intelligence of American schoolchildren: a randomized, double-blind placebo-controlled trial. *Journal of Alternative & Complementary Medicine* 2000 Feb;6(1):19-29.

CONTEXT: Many medical, nutrition, and education professionals have long suspected that poor diet impairs the academic performance of Western schoolchildren; academic performance often improves after improved diet. However, others have suggested that such academic gains may be due to psychologic effects rather than nutrition. To resolve this issue, two independent research teams conducted randomized trials in which children were given placebos or low-dose vitamin-mineral tablets designed to raise nutrient intake to the equivalent of a well-balanced diet. Both teams reported significantly greater gains in nonverbal intelligence among the supplemented

groups. The findings were important because of the apparent inadequacy of diet they revealed and the magnitude of the potential for increased intelligence. However, none of the ten subsequent replications, or the two original trials, were without limitations leaving this issue in controversy. OBJECTIVES: To determine if schoolchildren who consume low-dose vitamin-mineral tablets will have a significantly larger increase in nonverbal intelligence than children who consume placebos in a study that overcomes the primary criticisms directed at the previous 12 controlled trials. DESIGN: A double-blind, placebo-controlled trial using stratified randomization within each teacher's class based on preintervention nonverbal intelligence. SETTINGS AND SUBJECTS: Two "working class," primarily Hispanic, elementary schools in Phoenix, Arizona, participated in the study. Slightly more than half the teachers in each school distributed the tablets daily to 245 schoolchildren aged 6 to 12 years. INTERVENTION: Daily vitamin-mineral supplementation at 50% of the U.S. daily recommended allowance (RDA) for 3 months versus placebo.

Schoenthaler SJ, Bier ID. Vitamin-mineral intake and intelligence: a macrolevel analysis of randomized controlled trials. J Altern Complement Med 1999 Apr;5(2):125-34

CONTEXT: Two independent groups suspected that poor diets in school children might impair intelligence. Because dietary changes produce psychological effects, both groups conducted randomized trials in which children were challenged with placebo or vitamin-mineral tablets. Both reported significantly greater gains in intelligence among the actives. The findings were important because of the apparent inadequacy of diet they revealed, and the magnitude of the potential for increased intelligence. However, 5 of 11 replications were not significant, leaving the issue in doubt. OBJECTIVE: To determine if school children who receive low-dose vitamin-mineral tablets produce significantly higher IQ scores than children who receive placebo. DESIGN: A macrolevel analysis of the 13 known randomized, double-blind trials was undertaken. SETTING AND SUBJECTS: A total of 15 public schools in Arizona, California, Missouri, Oklahoma, Belgium, England, Scotland, and Wales participated, with 1477 school children, aged 6 to 17 years, and 276 young adult males, aged 18 to 25 years, in 2 American correctional facilities. MAIN OUTCOME MEASURES: All studies used 1 of 3 standardized tests of nonverbal intelligence: the Wechsler Intelligence Scale for Children-Revised, the Wechsler Adult Intelligence Scale, or the Calvert Non-verbal test. RESULTS: The activities in each study performed better, on average, than placebo in nonverbal IQ, regardless of formula, location, age, race, gender, or research team composition. The probability of 13 randomly selected experimental groups always performing better than 13 randomly selected independent control groups is one-half to the 13th power ($p = 0.000122$). The mean difference across all studies is 3.2 IQ points. Furthermore, the standard deviation in the variable "IQ change" was also consistently larger in each active group when compared to its controls. This confirms that a few children in each study, presumably the poorly nourished minority, were producing large differences, rather than a 3.2 point gain in all active children. CONCLUSION: There are important health risks when school children's dietary habits depart substantially from government guidelines; poor dietary habits may lead to impaired intelligence. Low-dose vitamin-mineral supplementation may restore the cognitive abilities of these children by raising low blood nutrient concentrations. However, there is also evidence that supplementation has no measurable effect on the intelligence of well-nourished children with normal blood nutrient concentrations. Publication Types: Meta-analysis

Schuitmaker, G. E. Nutrition and behaviour. Journal of Orthomolecular Medicine. Vol 3(2), American Assoc. of Orthomolecular Medicine. 1988, 57-60.

Reviews studies by D. Benton and G. Roberts (1988) on the effect of vitamin and mineral supplements on the intelligence of school children and by S. J. Schoenthaler et al (see record 1988-12155-001) on the influence of nutrition on behavior. (PsycINFO Database Record (c) 2000 APA, all rights reserved).

Sigman, Marian; Whaley, Shannon E. "The role of nutrition in the development of intelligence." In: Neisser, Ulric (Ed). (1998). *The rising curve: Long-term gains in IQ and related measures.* (pp. 155-182). Washington, DC, US: American Psychological Association. xv, 415 pp. ISBN 1-55798-503-0 (hardcover)

(from the chapter) The position taken by this chapter is that improvements in nutrition are likely to account, at least in part, for the worldwide rise in IQ scores. This conclusion is based on the research literature, reviewed in this chapter, indicating that nutrition and intelligence are linked. The purpose of this review is to present these findings and, at the same time, to outline the limitations in this research literature in the hope of encouraging more investigations. Specific issues addressed include: effects of severe malnutrition on children; effects of food supplementation on the cognitive development of young children; cognitive development in young children in relation to food intake; effects of mineral and vitamin supplementation on children; and processes mediating the association between nutrition and intelligence. (PsycINFO Database Record (c) 2000 APA, all rights reserved) Publication Type Book Chapter.

Singh, Mahendra P; Agrawal, Padma. Effect of nutrition on intellectual development.

Perspectives in Psychological Researches. Vol 10(2), Oct , 1987, 25-29.

An examination of the effect of nutrition on 58 Indian boys with and without Kwashiorkor showed that early dietary supplementation significantly elevated intelligence test scores of Ss above those whose life histories had been characterized by chronic malnutrition. (PsycINFO Database Record (c) 2000 APA, all rights reserved). Form/Content Type Empirical Study.

Smith WB. Commentary on Schoenthaler et al: vitamin and mineral supplements--is the methodology sufficient to support the conclusions? *J Altern Complement Med* 2000

Feb;6(1):31-5

Comment on:

J Altern Complement Med. 2000 Feb;6(1):19-29

J Altern Complement Med. 2000 Feb;6(1):7-17.

Snowden, Wendy. Evidence from an analysis of 2000 errors and omissions made in IQ tests by a small sample of schoolchildren, undergoing vitamin and mineral supplementation, that speed of processing is an important factor in IQ performance. *Personality & Individual Differences.* Vol 22(1), Jan.1997, 131-134.

30 9-10 yr olds were administered vitamin and mineral supplements or a placebo triple-blind for 10 wks to examine differences in IQ performance resulting from enhanced nutrition. A significant difference in increased non-verbal IQ scores was found, but no difference in verbal IQ scores between the 2 groups was demonstrated. An analysis of the errors and omissions made in the IQ tests indicates the error rate for the supplemented group remained stable but the number of omissions dropped significantly. Almost all omissions made in the 1st IQ test were at the end of the paper when the children ran out of time and so were unable to finish the paper. After 10 wks of supplementation, however, considerably more non-verbal IQ questions were completed and since the error rate remained the same this resulted in significant gains in non-verbal IQ. These data suggest that speed of processing is a significant factor in IQ performance and presumably in intelligence. (PsycINFO Database Record (c) 2000 APA, all rights reserved)Form/Content Type Empirical Study; Followup Study.

Southon S, Wright AJ, Finglas PM, Bailey AL, Loughridge JM, Walker AD.

Dietary intake and micronutrient status of adolescents: effect of vitamin and trace element supplementation on indices of status and performance in tests of verbal and non-verbal intelligence. *Br J Nutr* 1994 Jun;71(6):897-918.

Relationships between micronutrient intake and status, and micronutrient status and performance in tests of intelligence were investigated in a group of adolescents (13-14 years old). Dietary intakes were assessed using a 7 d weighed dietary record method, coupled with the collection of duplicate diets. Vitamin and trace mineral intakes calculated using food composition tables were compared with those obtained by direct analysis of duplicate diets. Micronutrient status was judged via a range of biochemical indices measured in blood samples taken after a 12-15 h fast. Blood samples were taken both before and after a 16-week period of vitamin and trace mineral supplementation. Individual tests of verbal and nonverbal intelligence were also performed pre- and post-supplementation. The results of this study indicate that the use of food table data may lead to substantial over- or underestimation of the intake of several micronutrients. In general, the total calculated or analysed amount of a specific micronutrient consumed did not adequately predict status, as judged by a range of biochemical indices. There were significant changes in status measurements over the 16-week study period, irrespective of supplementation, and these changes were markedly influenced by the initial status of the subject. There was no effect of supplementation on performance in tests of intelligence. However, there was a significant association between plasma ascorbic acid and initial non-verbal intelligence quotient (IQ) in the boys, and between whole blood glutathione peroxidase (EC 1.11.1.9) activity and non-verbal and verbal IQ in both sexes. These findings are discussed in relation to other recent studies of the influence of micronutrient supplementation on the psychological performance of children.

Soewondo S. The effect of iron deficiency and mental stimulation on Indonesian children's cognitive performance and development. *Kobe-J-Med-Sci.* 1995 Apr; 41(1-2): 1-17.

Abstract: Three studies conducted in Indonesia will be described. Soewondo (12) investigated the relation of iron deficiency and cognitive function and impact of iron supplementation on verbal intelligence, attention and concept learning among iron deficient children without anemia and iron deficient anemic children. Half of 176 children, aged 3-6 years, received elemental Fe for 8 weeks and the other half received placebo. There were significant changes from pre to post intervention evaluations in ferritin, transferrin saturation, free erythrocyte protoporphyrin, and hemoglobin in the iron deficient anemic children. Pre and post treatment psychological test data showed that iron deficiency anemia produced alterations in cognitive processes related to visual attention and concept acquisition. These alterations can be reversed with iron treatment.

Idjradinata (4) assessed the impact of iron supplementation on iron deficient infant's mental and psychomotor development. Hundred twenty six subjects aged 12 to 18 month were randomly assigned to either iron treatment or placebo intervention. After 4 months of iron supplementation, the hemoglobin, ferritin and transferrin saturation changed significantly in the iron deficient infants. A developmental delay was observed in the iron deficient anemic infants before intervention and the conditions were reversed after 4 months of iron treatment. Soemiarti (8) examined the effectiveness of a training course given to mothers of children aged 12 to 24 month on the rearing environment and consequently to the child's development. The subjects were 69 mothers of 20-35 years old. The training lasted for 21 days by giving mothers training using the program "Ibu Maju Anak Bermutu". The rearing environment improved, also the child's mental and psychomotor development.

Swensson, Marjorie. Nutrition and Its Effects on Learning.

43p.; M.S. Practicum, Nova University. 1990

ABSTRACT: A 12-week practicum intervention, designed to improve the classroom performance of 17 elementary school students experiencing learning or behavior problems by offering the students nutrition instruction and improving nutritional practices in the students' homes, was implemented and evaluated. Students were required to agree to: (1) eat a nutritious breakfast each morning; (2) limit sugar intake; (3) eat nutritious snacks; (4) eat more fruits, vegetables, whole-grain and protein-rich foods than previously; and (5) attend nutrition education classes two or

three times a week. Parents were encouraged to participate in the project. Nutrition classes provided discussions of films on nutrition topics, tasting parties, cooking experiences, parent education sessions, and instruction on reading labels. Effectiveness of the intervention was evaluated by observations of classroom behavior and pre- and posttesting with the Wide Range Achievement Test (WRAT) and a General Nutrition Quiz. Classroom observations revealed that 50 percent of the students had improved in behavior and were enjoying increased academic success. Most children who altered their eating habits scored higher on the posttest WRAT than those who had not. All participants learned the value of proper nutrition.

Todman, John; Crombie, Iain; Elder, Leona. An individual difference test of the effect of vitamin supplementation on non-verbal IQ. *Personality & Individual Differences*. Vol 12(12), 1991, 1333-1337.

Elaborates on D. Benton and G. Roberts's (1988) study that found an effect of vitamin and mineral supplementation on the nonverbal IQs of schoolchildren and the I. K. Crombie et al (1990) replication, which found no such effect. In the latter study, 2 of the nonverbal tests employed did show small, nonsignificant effects in the same direction as the original study. 40 schoolchildren (mean age 11.86 yrs) participated in a further study in which these 2 tests were taken and then retaken after training in nonverbal reasoning. A significant correlation was found between change scores when the independent variable was training, but not when it was vitamin supplementation, thus questioning the validity of the original study. (PsycINFO Database Record (c) 2000 APA, all rights reserved) Form/Content Type Empirical Study.

U.S. Congress 102nd. Meeting the Goals: Collaborating for Youth. Hearing Before the Committee on Labor and Human Resources, United States Senate. One Hundred Second Congress, First Session. On Examining the Need To Provide Comprehensive Services To Youth To Help the Nation Meet the Education Goals of School Readiness, Dropout Prevention, Improved School Achievement, and Drug and Violence Free Schools and To Examine What the Federal Government Can Do To Support and Expand Social Service Programs for Youth. U.S. Government Printing Office, Superintendent of Documents, Congressional Sales Office, Washington, DC 20402. 1991

ABSTRACT: A hearing before the U.S. Senate Committee on Labor and Human Resources examined the need for provision of comprehensive services to youth. Topics discussed included: (1) the provision of coordinated social services to students and families in schools; (2) school readiness; (3) dropout prevention; (4) improved school achievement; (5) drug- and violence-free schools; and (6) child health and nutrition. Statements were made by Chairman Kennedy and other senators, and by spokespersons for several social service programs. Programs included: (1) programs in New Jersey that bring social services into the schools; (2) programs in Arkansas that serve children and students; (3) the Dunbar Project, which provides an array of services to six schools in Baltimore, Maryland; (4) Joining Forces, a national effort to join students with appropriate social services; (5) New Beginnings, which provides integrated services for children and families in San Diego, California; (6) programs to assist students in Boston, Massachusetts; (7) YouthNet, a youth development collaboration established by 12 agencies in Kansas City, Missouri; and (8) the Family Learning Center, a rural, comprehensive, secondary education program for teenage parents and their children and extended families in Leslie, Michigan.

van den Briel T, West CE, Bleichrodt N, van de Vijver FJ, Ategbo EA, Hautvast JG. Improved iodine status is associated with improved mental performance of schoolchildren in Benin. *Am J Clin Nutr* 2000 Nov;72(5):1179-85

BACKGROUND: An adequate iodine supply in utero and shortly after birth is known to be crucial to an individual's physical and mental development. The question of whether iodine supplementation later in life can exert a favorable influence on the mental performance of iodine-

deficient populations was addressed in various studies, but with contradictory results.

OBJECTIVE: The aim of this study was to examine the effect of an improvement in iodine status on mental and psychomotor performance of schoolchildren (7-11 y) who were moderately to severely iodine deficient. **DESIGN:** The study, which was originally planned as a double-blind, randomized, placebo-controlled intervention, was carried out in an iodine-deficient population of schoolchildren (n = 196) in northern Benin. As the population began to have access to iodized salt during the 1-y intervention period, the study population was split post hoc on the basis of urinary iodine concentrations into a group with improved iodine status and a group with unchanged iodine status. Changes in mental and psychomotor performance over the intervention period were compared. **RESULTS:** Children with increased urinary iodine concentrations had a significantly greater increase in performance on the combination of mental tests than did the group with no change in urinary iodine concentrations. **CONCLUSIONS:** An improvement in iodine status, rather than iodine status itself, determined mental performance in this population, which was initially iodine deficient. These findings suggest a "catch-up" effect in terms of mental performance. **Publication Types:** Clinical trial Randomized controlled trial

Vitamin claims challenged. Times 1988 Aug 12.

Larkhall Laboratories, of Putney, SW London, the drug company which claims its vitamin supplements can improve childrens' intelligence, is coming in for increasing criticism. The Lancet last year carried the result of a study at a school in Clwyd where childrens' performances were measured after a course of vitamin tablets. The Headmaster of the school has since resigned, and written a book on the subject; he is now employed by Larkhall to promote their "IQ pack". Recently, doctors at Kings College Food and Nutritional Sciences department published in the Lancet their results of a similar trial among children. One group was given the tablets, with the other was given a placebo. The result was 'no difference in performance between the two groups'. Earlier this year, other researchers have criticized or challenged the original findings, but Larkhall Laboratories stand firmly by their results, and are planning further larger studies.

Vitamin/mineral supplementation and non-verbal intelligence.

Lancet 1988 Feb 20;1(8582):407-9

Publication Types: Letter

Walker SP, Grantham McGregor SM, Powell CA, Chang SM. Effects of growth restriction in early childhood on growth, IQ, and cognition at age 11 to 12 years and the benefits of nutritional supplementation and psychosocial stimulation. J-Pediatr. 2000 Jul; 137(1): 36-41 2000.

OBJECTIVES: (1) To determine whether benefits to growth and cognition remain after intervention in growth-restricted children who received psychosocial stimulation and nutritional supplementation in early childhood. (2) To investigate the extent of the differences in IQ and cognition at age 11 to 12 years between growth-restricted and non-growth-restricted children.

STUDY DESIGN: Growth-restricted and non-growth-restricted children were identified at age 9 to 24 months, at which time the growth-restricted children participated in a 2-year randomized trial of nutritional supplementation and psychosocial stimulation. Eight years after the interventions ended, the children's growth, IQ, and cognitive functions were measured.

RESULTS: There were no significant benefits from supplementation to growth or cognition. Children who had received stimulation had higher scores on the Weschler Intelligence Scales for Children-Revised full-scale (IQ) and verbal scale and tests of vocabulary and reasoning (all P <.05). The growth-restricted children had significantly lower scores than the non-growth-restricted children on 10 of 11 cognitive tests. **CONCLUSIONS:** Psychosocial stimulation had small but significant long-term benefits on cognition in growth-restricted children. Growth-restricted children had significantly poorer performance than non-growth-restricted children on a

wide range of cognitive tests, supporting the conclusion that growth restriction has long-term functional consequences.

Weissberg Roger P, Gullota, Thomas P, Hampton Robert L, Ryan Bruce A, Adams Gerald R. Enhancing Children's Wellness. Healthy Children 2010. Issues in Children's and Families' Lives, Volume 8. The John & Kelly Hartman Series. Sage Publications Inc., 2455 Teller Road, Thousand Oaks, CA 91320. 1997

ABSTRACT: This volume consists of 10 chapters which emphasize the latest research and theories about family, school, and community prevention programs and health promotion programs to improve the health status of children during the next decade. The goal of the volume is to influence the nation's policies and practices regarding children's health by raising awareness about effective and theoretically based prevention programs and strategies. The chapters address issues of problem behaviors coupled with substance abuse, delinquency, and school failure; drug abuse prevention; unwanted pregnancy; AIDS; violent and aggressive behavior; depression and suicide; and childhood injury. After a foreword by Seymour B. Sarason, the 10 articles are: (1) "Introduction and Overview: Let's Make 'Healthy Children 2010' a National Priority!" (Weissberg and Kuster); (2) "The Prevalence of Problem Behaviors: Implications for Programs" (Dryfoos); (3) "School-Based Drug Abuse Prevention Strategies: From Research to Policy and Practice" (Dusenbury and Falco); (4) "Preventing High-Risk Sexual Behavior, Sexually Transmitted Diseases, and Pregnancy Among Adolescents" (Sagrestano and Paikoff); (5) "Violence Prevention for the 21st Century" (Murray, Guerra, and Williams); (6) "Prevention of Depression" (Compas, Connor, and Wadsworth); (7) "Prevention of Youth Suicide" (Kalafat); (8) "Promoting Healthy Dietary Behaviors" (Perry, Story, and Lytle); (9) "Prevention and Control of Injuries" (Tuchfarber, Zins, and Jason); and (10) "Academic Performance and School Success: Sources and Consequences" (Hawkins). (SD)

Yudkin, John. Intelligence of children and vitamin-mineral supplements: The DRF study: Discussion, conclusion and consequences. Personality & Individual Differences. Vol 12(4), 1991, 363-365.

Reviews the literature supporting the claim that supplementing elementary school children's diet with vitamins increases their IQ scores. Questions raised by these findings are addressed, including why IQ was only increased by a particular level of supplementation and which nutrients in the supplement were responsible for the improvement. (PsycINFO Database Record (c) 2000 APA, all rights reserved)