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A Study for the Effect of Blood Hemoglobin Level And Some Related Nutrients on Scholastic Achievement and Attention in Elementary School Children

By

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Introduction :

There is an array of nutritional and health problems prevailing among school children in developing countries. These include short term hunger and protein-energy malnutrition; micronutrient deficiencies such as those of iron, iodine, and vitamin C, and certain disabilities (visual, auditory, physical). Those unfortunate children often face many educational difficulties, i.e., in enrollment, attendance, repetition, high dropout rates, poor school performance, and low general achievement. Cognition and alertness and other psychological factors are involved in such activities.

Objectives :

What are the connections between these two sets of problems; nutritional and health problems on one hand and educational outcomes on the other ?

This question, motivated the researcher to carry out the present study, has been raised at the " First International meeting of the UNESCO project to improve Primary School Performance through Natrition and Health Intervention, held at the Wenner-Gren Foundation headquarters in Stockholm, April 3 - 5, 1989 (Latham, 1989).

Another reason for conducting such a study is the paucity, if not the total absence of research linking nutrition and health matters to academic performance, in Egypt.

It is hoped that this research might help draw the attention of other researchers to study the effects of nature and nutriture on academic achievement and its implications for developing programs to ameliorate the educational process in our schools.

In this study: Hemoglobin concentration in red blood cells dietary intakes of iron, and vitamin C (Ascorbic acid) were assessed in a large sample of school children, in order to investigate their effects as descriptive independent variables on alertness and school achievement (dependent variables) in those children.

Review of litterature :

Previous research have shown that Hemoglobin and Hematocrit measurements are by far the most commonly performed clinical tests for the purpose of detecting anemia (Yip, 1989). There are many causes for anemia: however it is well accepted that iron deficiency is the most common cause. And although anemia is frequently defined in terms of hemoglobin concentration, low hemoglobin should not be the sole criterion for the diagnosis of iron deficiency anemia (Johnson and Futrell, 1974).

Iron is found in all cells and body tissues. It is crucial for many biochemical reactions in the body. Most of the body's iron is found in hemoglobin; the approximately 73% of the body's iron is normally incorporated into hemoglobin, a very important 15% is incorporated into a variety of other iron containing compounds some of them enzymes of vital importance, and 12% in the storage complexes ferritin and hemosiderin (Schrimschaw, 1989), principal components of red blood cells. Hemoglobin combines with oxygen in the lungs and releases oxygen in the tissues whenever a need exists. It also aids in the return of carbon dioxide from tissues to the lungs. In addition to its role in oxygen transport, iron is a structural component of or a cofactor with a number of enzymes essential in oxidative metabolism: DNA synthesis, and neurotransmitter synthesis and degradation (Kanarek and Marks-Kaufman, 1991; Spurr, 1989). The absorption of iron from food is, however, influenced by a variety of factors, and thus the iron content of a food does not always provide a true picture of this mineral availability. Ascorbic Acid (vitamin C) forms a soluble complex with iron that results in the enhancement absorption of this mineral (Zajka-Narins et al., 1978). Iron and ascorbic acid intake were correlated significantly ($r = 0.28$, $P < 0.01$) in a study investigating anemia prevalence among black preschool children in the United States of America (Johnson and Futrell, 1974).

Analysis of the brain by region demonstrates that the basal ganglia and some associated structures, constituting the extrapyramidal motor system, are particularly rich in iron. Iron containing enzymes; tyrosine hydroxylase is found in largest amount in those parts of the brain where dopamine (tyrosine is the precursor for dopamine) is a principal neurotransmitter, and must be provided in adquate amounts for regulation of tone and posture of the limbs, as well as other functions. Tryptophan hydroxylase, is found, in the serotonin-synthesizing areas of the brain (tryptophan is the precursor for serotonin), i.e. the midbrain Raphé nuclei and their terminal projections. (Spurr and Reina, 1986). Spurr (1989) summarizes research on iron deficiency and physical capacity of the individuals by saying " There is no question that the reduced oxygen carrying capacity of arterial blood which occurs in acute or chronic anemia results in the physical work capacity of individuals, with obvious implications for productivity in heavy physical work ".

Iron role in brain function and dysfunction were not considered until relatively recently, this is rather surprising since iron is an essential participant in many metabolic processes including DNA, RNA, and protein synthesis. A deficiency of iron metabolism would therefore be expected to alter some or all of these processes. In addition to that there are behavioral consequences of iron deficiency which frequently include irritability, shortened attention span, pica, hypoactivity, altered sleep pattern, and decreased IQ, and other clinical symptoms (Kanarek and Marks-Kaufman, 1991; Youdim, 1989).

Researchers found that children with iron deficiency anemia had more illnesses and more behavioral problems than those in a control group. (Johnson and Futrell, 1974). In a study on 450 black children in a Head Start program in New Orleans; researchers used a variety of measures of psychological functions. It was found that children with low hemoglobin levels (below 10.5 gm/100 ml.), showed significantly poorer scores on verbel and performance tests of intelligence, and on measures of associative reaction time. No differences were found on certain other measures, notably moral judgement. syntactic complexity. object sorting, and short-term memory (Sulzer and Hansche. 1970).

In a recent research, relationships between brain function and iron nutriture have been studied in infants. children. and young adults. Palti and colleagues (Cited in, Sandstead, 1989) measured indices of brain function at 24, 36, and 60 months of age in children who attended the Preventive Maternal and-Child Health Service of western Jerusalem, and who had had hemoglobin measured at nine months of age. Twenty percent of the children displayed hemoglobin levels between 10.9 and 10.09/dL, while 9.5 % had lower levels, Height was significantly ($P < 0.04$) associated with hemoglobin levels in males, and marginally so in females ($P = 0.10$). As for the effect of lower hemoglobin on cognitive, a seven point I.Q. difference, in five year old children who had lower hemoglobin levels (8.09/dL) as compared to the other children of higher level hemoglobin (12.09/dL) was predicted when birth weight, sex, and mother's education were constant. Other researchers found that iron-deficient children were less attentive (Sandstead, 1989).

In a review for research of iron deficiency effect on cognition and behavior, it was shown that on a battery of cognitive and behavioral tests,mildly iron deficient 3 - 6 years old children in Cambridge, Massachusetts had lower scores than those with normal iron status, but the low scores returned to normal after the children were given supplementary oral iron for 11 - 12 weeks (Scrimshaw, 1989).

A study was done in Egypt (Pollitt et al., 1984) investigated the effect of iron depleted and iron repleted. children. Iron deficient and iron sufficient children were classified on the basis of several criteria among which was the hemoglobin levels. subjects treated with iron (repleted groups) scored higher than subjects given placebo. on a test for Matching Familiar Figures.

Subjects :

205 school children from a village called Atries, Giza Governorate, and 200 school children from the New Valley governorate were randomly recruited to take part in this study*.

The researchers visited The New Valley. stayed there for two weeks, and went into Atries three months later. after the chemical assays of blood samples of the New Valley children were done with. In Atries, she stayed one week.

Materials and Methods :

A blood sample (one drop) was taken from each child's thumb using a sterilized lancet.

After the collection of the blood samples. each child was interviewed individually; asked to recall his/her last 24 -hr food intake. Chemical assay of hemoglobin levels in blood samples as well as assessments of food-intakes recall for the availability of iron and vitamin C were done by the researcher, so were the individual interviews of the children.

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* The researcher would like to thank the principals of the schools of those areas for making the children's files available for her.

After that, children were assembled in small groups, Fifteen children at most, for the psychological testing.

Table (1) shows the details of the children samples.

Table (1) shows sex and numbers of the Atries and the New Valley school children samples.

Area	Boys			Girls			t-test value
	n	Age X	Age s.d.	n	Age X	Age s.d.	
Atries	106	10.860	1.440	99	10.930	1.442	0.348
The New Valley	109	10.520	1.480	91	10.516	1.490	0.00
t-test value		1.707			1.927		

All children, boys and girls were enrolled, at the time of the visit, in the fourth or the fifth grade of the elementary schools of both regions; the New Valley and Atries.

1. Information of food intake recall for the last 24 - hr was collected using a questionnaire, prepared for that purpose. That questionnaire asks subject to ennumerate kinds and amounts of food he/she takes in and between meals for the recent 24 - hr. The researcher undertook the task of transforming this information into quantitative amounts, in particular the two nutrients; iron and vitamin C. That quantification is done in accordance to standard prepared tables (Nutrition Institute-Food Composition tables, 1985).

2. As is previously mentioned, blood samples were taken. and were collected in heparinized pasteur pipettes. The samples were pipetted in labied Eppendorf micro reaction vessels: these vessels were placed in thermos flask on ice until it was transported to the laboratory. Determination of hemoglobin was done by the cyanomethemoglobin method* (Intern. Commit. For standard Hemat., 1965).
3. Two tests measure mental alertness, or attention and concentration were used in this study kraeplin's letter canellation, and an arithmetic problems test. These two tests were used in previous research and, are described elsewhere (Tawfik and Abosheasha , 1994).

Children were brought in small groups into a classroom at one school, that was done in the New Valley and in Atries school. They were instructed on the way of responding to the letter cancellation and the arithmetic problems test, told frequently that speed of performance was a primary requirement these two tests were marked for performance speed and accuracy. A score on each test was assigned to each child. Scoring procedures were also explained in previons research (Tawfik and Abosheasha, 1994).

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Results :

Table (2) shows the means and the standard deviations of all the six variables; hemoglobin, Iron, vitamin C. cancellation, Arithmetic problems, and scholastic achievement scores, for boys and girls of both Atries and New valley.

Table (2) shows the means and standard deviations of hemoglobin levels, Iron, and vitamin (intakes by region and sex of subjects).

Area	N	Hemoglobin g/100 mL	Iron mg/day	Vitamin C mg/day	Letter canc.	Arithm	Scholastic Ach.
Atries, Boys	106	10.32 (1.46)	26.72 (11.12)	26.93 (20.42)	3.64 (3.30)	0.47 (0.25)	170.02 (35.28)
Atries, Girls	99	10.57 (1.59)	18.92 (10.68)	16.61 (16.22)	3.13 (2.89)	0.32 (0.29)	167.43 (36.11)
t =		1.174	5.115**	3.989**	1.174	3.974**	0.519
New Valley, Boys	109	12.57 (2.15)	23.51 (9.13)	28.95 (27.08)	3.16 (2.33)	0.48 (0.32)	192.82 (32.78)
New Valley, Girls	91	12.47 (2.56)	19.97 (16.59)	51.14 (40.42)	3.49 (2.66)	0.79 (0.32)	193.03 (25.38)
t =		0.300	1.909	4.623**	0.953	6.822**	0.050

* Significant at 0.05 level.

** Significant 0.01 level.

The following table shows the correlations between the six variables of the study for the two samples of Atries and the New valley, boys and girls groups are combined at the calculation of the correlation coefficients for each region.

Table (3) correlation between the six variables of the study, by region.

Variable	Hemog.	Iron	Vit. C	Canc.	Arith.	Ach.
Hemoglobin	-					
Iron	.079					
	.011					
Vitamin C	.089	.370**				
	.009	.195**				
Cancellation	.073	.027	-.068			
	.180*	.178*	.127			
Arithmetic	.630**	.105	.236**	.100		
	.122	-.006	.144	.160*		
Scholastic Ach.	.225**	-.056	.163*	.105	.050	
	.310**	-.017	.194**	.505**	.235**	

Atries correlations are up. New valley correlations are down.

* r significant at .05 level.

** r significant .01 level. } one-tailed test

(Ferguson and Takane, 1989).

Because nutritionists consider a person with hemoglobin level below 9.0g/100 ml to be anemic, It was thought of classifying The subjects; males and females with respect to hemoglobin into two groups; subjects whose hemoglobin levels are equal or above 12g/100 ml and those whose hemoglobin levels are below 9.0 g/100 ml.

Boys and girls of each area were again classified with respect to Iron and vitamin C intakes to : those who are above the recommended daily allowances and those who are below the recommend daily allowances for the respective ages

(RDA, 1989). X^2 between the dichotomized variables: hemoglobin, Iron, and vitamin C on one-hand, and letter cancellation., Arithmetic test, and scholastic Achievement results, on the other, were calculated. Table (4) shows the results of X^2s.

Table (4) X^2 - or dependence between the independent and dependent measures, for Boys and Girls.

Dependent Var. / Independent Var.	cancellation test = $\overline{X}$ = 3.2		Arithmetic $\overline{X}$ = 0.52		Scholastic Ach. $\overline{X}$ = 181.0	
	< 3.32	≥ 3.32	< 0.52	≥ 0.52	< 181.0	≥ 181.0
Hemoglobin :						
Boys < 9.0	16	4	18	2	11	9
Boys ≥ 12.0	24	24	13	35	9	39
X^2	4.080*		20.064**		8.936**	
Girls < 9.0	8	5	12	1	9	4
Girls ≥ 12.0	25	22	15	32	9	38
X^2	0.049		12.666**		9.895**	
Iron :						
Boys < 12.0	10	2	4	13	7	6
Boys ≥ 12.0	68	32	13	32	45	55
X^2	0.577		0.011		0.362	
Girls < 12.0	9	6	10	4	5	9
Girls ≥ 12.0	45	29	34	29	35	39
X^2	0.053		0.802		0.637	
Vitamin C :						
Boys < 47.0	58	19	41	26	45	38
Boys ≥ 47.0	18	12	17	10	10	19
X^2	2.464		0.025		3.349	
Girls < 47.0	39	33	36	22	36	31
Girls ≥ 47.0	10	7	5	12	2	16
X^2	0.121		5.658*		8.773**	

* X^2 significant at 0.05 level.

** X^2 significant at 0.01 level.

Discussion of the Results :

1. Table (1) shows that there are no significant age differences between boys and girls of the two region-samples.
2. A significant difference in iron intake. was found between boys and girls of the Atries region only, table (2). There were significant difference in vitamin C intake between boys and girls both in Atries and the New valley regions. However, the differences are not in the same direction. Boys are higher than girls in iron intake in Atries. and Girls had higher intake than boys in the New valley region.
3. As for the three dependent variables; letter cancellation, Arithmetic test, both measure attention, and scholastic achievement; only the arithmetic test has detected significant differences between the boys and the girls in both region-samples; however in opposite directions.

It is appropriate to attribute differences between the two sexes on Arithmetic test (Atention) to the differences between them in iron and vitamin C intake. However this explanation might prove correct only in the case of Atries two groups (boys and girls) since the differences between the two sexes on Iron and vitamin C intakes are in the same direction as the differences between them in attention, as measured by the Arithmetic test. With respect to the two groups of the New valley; (a) Boys had higher iron intake than girls, though the difference is significant at 0.10 only. (b) Girls had higher intake of vitamin C than boys, and the difference is significant

($P < 0.01$). On the dependent variable, attention - as measured by the arithmetic test, the difference between boys and girls is significant, girls are higher.

Difference between them on this dependent variable then must be due to difference in vitamin C intake. However, the differences in iron and vitamin C intake and on attention (the Arithmetic problems test) are in the interest of the boys of the Atries samples and the differences in vitamin C and attention are in the interest of the girls of the New Valley samples.

The conclusion deduced from the previous results is that : Iron, and vitamin C intakes had positive effects on attention only in boys of Atries. And, vitamin C intake had positive effects on attention only in girls of the New valley.

Table (3); however, shows significant correlations between hemoglobin, iron, and vitamin C intakes, on one hand as independent variables, and cancelation test. Arithmetic test, and scholastic achievement scores. This is true for Atries boys and girls (as one group) and the New valley boys and girls (as one group).

Values of hemoglobin, iron, and vitamin C were dichotomized on a specific cut-point for each. So also were the dependent variables of attention and scholastic achievement. Calculated X^2s between the two groups of variables ascertain the correlations of table (3).

High correlations between hemoglobin and the two tests of attention and scholastic achievement, in the two region samples were obtained (table 3), and for all boys and all girls alike (table 4). Iron correlated significantly only once with a test for attention (cancellation), in the New Valley group (table 3). Table (4) showed no dependence between iron intake and neither of the attention measures, nor the scholastic achievement scores.

Highly significant correlations between; vitamin C and one attention measure (arithmetic), and the scholastic scores were found (table 3). Table (4) shows dependence between vitamin C intake and both attention (arithmetic) and the achievement scores. That dependence was significant only for girls.

General conclusion :

Strong relationships were found between two of the three independent variables (hemoglobin and vitamin C intake) with the dependent variables of this study; namely : attention and the composite score of the scholastic achievement. This is true for two samples from the two different communities. Iron intake had shown no prominent effect, in this study, on attention except once with the cancellation test However, previous research ascertain the existence of such relationship (Scrimshaw, 1989).

Finaly, this study, is the first to report a relation between vitamin C intake and both attention and achievement. No previous research has taken interest in verifying such relation. Vitamin C intake has correlated with iron intake. r = 0.370 and .195, $P > 0.01$, and $P < 0.05$, one-tail test, respectively in agreement with previous research (Johnson and Futrell, 1974). It seems like iron intake is different from the amounts of iron absorbed in the body, and incorporated into hemoglobin.

This is true in view of the zero correlations obtained between iron intake and hemoglobin levels in the individuals.

Replications of such study are required, and observed ingested amounts of iron and vitamin C, rather than that recalled, is preferable in future research.

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الملخص العربي

استخدمت في هذه الدراسة عينتين كبيرتين ، إحداهما ٢٠٥ مفحوصاً : ١٠٦ طفلاً ، ٩٩ طفلة من إحدى قرى محافظة الجيزة . والعينة الثانية ٢٠٠ مفحوصاً : ١٠٩ طفلاً ، ٩١ طفلة من مناطق مختلفة بمحافظة الوادى الجديد . وكانت متوسط أعمار الأطفال جميعاً ١٠٫٧١ سنة بانحراف معيارى ١٫٤٦٣ .

وقد تم في هذا البحث : أولاً تقدير هيموجلوبين الدم لأفراد العينة ، ثانياً تقدير كميات ڤيتامين جـ ، والحديد التى تحتويها الأطعمة التى تناولها هؤلاء الأطفال باستخدام طريقة التذكر للأربع وعشرين ساعة الماضية ، ثالثاً تطبيق اختبارين يقيسان الانتباه « الشطب ، الحساب » بالاضافة إلى الحصول على درجات التحصيل الدراسى لهؤلاء الأطفال من ملفاتهم بالمدرسة .

وقد بينت النتائج وجود معاملات ارتباط مرتفعة بين قياسات الهيموجلوبين والأداء على اختبارى الانتباه والتحصيل المدرسى ، كذلك ظهرت ارتباطات دالة إحصائياً بين المتناول من أطعمة تحتوى على الحديد والمتناول من ڤيتامين جـ . ووجدت ارتباطات دالة بين المتناول من ڤيتامين جـ والتحصيل الدراسى ، وكذلك بين المتناول من الحديد واختبار الشطب .

هذه النتائج فى مجموعها تؤكد على العلاقة بين التغذية الجيدة والأداءات العقلية .

A Study for the Effect of Blood Hemoglobin Level And Some Related Nutrients on Scholastic Achievement and Attention in Elementary School Children

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Abstract

A large sample of; 205 school-children : 106 boy, and 99 girls from a village adjoining Giza Governorate; and 200 school-children; 109 boys and 91 girls taken from different locations in the New Valley Governorate. Average age of the sample is 10.71 years old, and a standard deviation of 1.463 years.

In this study, blood hemoglobin was measured for the subjects, the 24-hr recall method was used in estimating the quantities of iron and vitamin C, contained in the food ingested during the last 24 hours. Thirdly : two measures for attention " cancellation, and arithmetic " were administered, in addition the schoolastic achievement scores taken from the child's file at school was also obtained.

Results have shown highly significant correlation coefficients between hemoglobin levels and the children's performances on the two tests of attention and the achievement scores. There was also strong correlation between vitamin C and achievement scores, Iron and the cancellation test, and a significant intercorrelation between iron and vitamin C.

The results in whole assert the relationship between good nutrition and cognitive performances.