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Association Between Micronutrient Intake and Cognitive Performance of School-Aged Children Attending Selected Private Schools in Lagos State

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Abstract

Background: It has been reported that the academic performance of school-aged children has been on the decline in recent years. Feeding pattern determines micronutrient consumption and plays an important role in cognitive performance.

Objectives: This research assessed the micronutrient consumption, feeding pattern, and cognitive performance of school-aged children in selected private schools in Lagos State.

Methods: The socio-demographic characteristics of the parents and children, knowledge of parents on micronutrients, feeding pattern of the children, and identifying micronutrient-rich food among consumed foods were obtained using a semi-structured questionnaire. The micronutrient intake was assessed using twenty-four-hour dietary recall and the cognitive performance of the respondents was evaluated with structured questions from Slosson's intelligence test revised third edition after which the micronutrient consumption was correlated against overall cognitive performance using Pearson's multiple correlation range test.

Results: The results indicated that the feeding pattern of the children showed that 51.3% were fed three times a day, 47.3% took snacks at least once a day and more than half (52.0%) took fruits and vegetables once a day. The micronutrient-rich foods among consumed foods were identified and they include *efo* and *egusi, ewedu*, okro, apple, orange, and milk, among others. There was a negative correlation (p<0.05) between micronutrient consumption and cognitive performance among the students studied.

Conclusion: This study concludes that an increase in micronutrient consumption alone does not increase cognitive performance.

Keywords: *Cognitive Performance, Feeding Pattern, Micronutrient Consumption, School-aged children.*

Introduction

Micronutrient malnutrition affects the health and survival of more than 2 billion people worldwide (1). The Nutritional status of school aged children impacts their health and cognition and subsequently their educational achievement (2). Micronutrients are essential in the early stages of a child's development.

Improving intake of some micronutrients like iron and iodine has been shown to be an effective strategy to enhance cognitive performance in children (3), individual's perceptions, memory, thinking reasoning and awareness (4). Cognitive development refers to the changes of the cognitive process observed by batteries of intelligence tests assessing specific cognitive abilities. Cognitive development is determined by a number of factors, including socio- cultural, biological, and psycho-social variables and by genetic variation.

Nutritional deprivation during the school age years can further constrain the physical and cognitive development of school aged children, it is evident that school aged children suffer from micronutrient deficiencies and malnutrition (1). Undernutrition and overnutrition during school years can inhibit the physical and mental development of a child (5). Micronutrient malnutrition impairs the cognitive performance and development potential of children (6). Nutrition can have an impact on cognitive functioning directly or indirectly; directly nutrients are required as building blocks of the brain

structures and for the synthesis and function of neurotransmitters, indirectly nutrition enhances cognitive development through improvement of health and energy metabolism (7).

School age refers to the period in which a child attains basic primary education and it is a crucial period of growth and development. School age children between the ages of 5-9 years of age, school age children have rapid rate of growth and development hence they have increased nutrient requirement and most especially increased energy requirement because the body organs, systems and tissues are not fully developed at this stage.

Feeding pattern has a significant influence on the nutritional status and health of children, certain factors like preferences, ethnicity, values habits and availability affect dietary pattern and hence determine the health and nutritional status of people (8).

It is known that nutritional well-being is not only related to dietary adequacy and quality, but also to the process of feeding and parenting psychosocial determinants. Some of which are areas like cognitive stimulation, caregiver sensitivity and responsiveness to the child (9). Parenting styles and feeding practices can influence a child's nutritional status and compromised nutritional status in early childhood can lead to neuro-cognitive impairments persisting into adulthood despite complete catch-up physical growth at adolescence (10). Feeding pattern is a personal behavior that is developed over the years and may be influenced by physiological and social factors the type of food and amount of food an individual chooses to eat affects the overall well-being of the individual.

Diet plays a big role on our health and wellbeing and ensuring that children eat well is one of the ways to take care of the child (11), a healthy diet gives energy to go through the day it supports growth boosts immunity and protects against infections and diseases, an unhealthy diet results in malnutrition which is detrimental to the health and well-being of children affecting physical growth and mental development.

Nutritional deprivation in children negatively impacts the attainment of their full growth potential and mental development (12). The impact of nutrition on brain and cognitive performance sometimes depends on the timing of the nutritional impact during the Child's lifespan (13). Proper nutrition is important for normal growth, resistance to infection long term health and optimal neurologic and cognitive development in infancy. Nutrition affects the architecture of the brain and it can also potentially influence functioning from time to time, although the adult brain represents only 2% of the body weight it is responsible for 20% of basal metabolic rate (14). In spite of advocacy for health and nutrition services in primary schools, there is lack of data on the actual nutritional status of children in these age group in developing countries. Hence this research assessed the micronutrient consumption, feeding pattern and cognitive performance of school-aged children in selected private schools in Lagos State, Nigeria.

Materials and Methods

Study Design

A cross-sectional study was performed to determine the micronutrient consumption feeding pattern and cognitive performance of school aged children among selected private schools in Ikeja Local Government, Lagos State.

Sample size calculation

The sample size was calculated using Taro Yamane Formula (15).

The total population (N) of Ikeja local government is 317,614 (16)

$$n=\frac{N}{1+N(e)^2}$$

Where n is the sample size, N is the population size and e is the level of precision (0.05)

$$n = \frac{317,614}{1+316,614(0.05)^2}$$

$$n = \frac{317,614}{1+794.035}$$

n = 399.5.

The total number of school aged children in Ikeja Local government is 58,962 (16) which is 18.6% of the population, the percentage of the number of school aged children was calculated against n to give a sample size of 74 and this was doubled (148) to achieve optimum cross-sectional result and also approximated to 150.

Data collection

A semi-structured questionnaire was used for data collection. The questionnaire included questions on the demographic characteristics of the parents and children, the parents' knowledge of micronutrients and questions on the feeding pattern of the children was also gotten from the parents. An interview was conducted to assess the micronutrient intake of the children using a standard twenty-four hours dietary recall sheet and the children were interviewed for cognitive performance using twenty structured questions from Slossons intelligence test revised third edition.

Data Analysis

Statistical analysis was done using the Statistical Package for Social Sciences (SPSS) version 20.0. Descriptive statistics such as frequencies, percentages, means and standard deviation were used for socio-demographic characteristics, parents' knowledge on micronutrients feeding pattern of the children and cognitive performance of the children. Total dietary assessment (TDA) was used to analyze the micronutrient intake of the children, and Pearson's Correlation was used to establish the relationship between micronutrient consumption and overall cognitive performance of the children.

Results

The socio demographic characteristics of respondents are shown in Table 1, majority (67.4%) of the respondents were between the ages of 6-8 years, 11.3% of them were

age 5 years and 21.3% of them were between ages 9-10 years. About half (51.3%) of the respondents were males and 48.7% were females. Some (29.3%) of the respondents in primary 3, 22.7% in primary 4, 13.3% were in primary 5, 12.7 % were in primary 6 and the other 9.3% of the children were in primary 1. Majority (85.3%) of the respondents were Christians, 14.0% were Muslims and 0.7% had other religious affiliations. More than half (57.3%) of the respondents were Yoruba, 33.3% were Igbo and 9.4% were from other tribes. Almost all (97.3%) of the respondents were from monogamous homes while 2.0 % were from polygamous homes. Close to half (45.3%) of the respondent's parents earned less than 51,000, 30.0% earned between 51,000- 100,000, 22.7% earned between 101,000-200,000 and 2.0% of them earned above 200,000.

Table 1: Socio-Demographic Variables of Respondents

Indicators		Frequency (N=150)	Percentage (%)
Age (years)	5	17	11.3
	6	31	20.7
	7	37	24.7
	8	33	22.0
	9	11	7.3
	10	21	14.0
Sex	Male	77	51.3
	Female	73	48.7
Education	Primary 1	14	9.3
	Primary 2	34	22.7
	Primary 3	44	29.3
	Primary 4	19	12.7
	Primary 5	20	13.3
	Primary 6	19	12.7
Religion	Christian	128	85.3
	Muslim	21	14.0
	Others	1	0.7
Tribe	Yoruba	86	57.3
	Hausa	7	4.7
	Igbo	50	33.3
	Others	7	4.7
Family	Monogamy	146	97.3
	Polygamy	3	2.0
	No response	1	0.7
Parents' Income (N)	Less than 51,000	68	45.3
	51,000-100,000	45	30.0
	101,000-200,000	34	22.7
	Above 200,000	3	2.0

Table 2 showed that 82.0% of the parents had heard the word micronutrient while 18.0% had not. More than half (63.3%) of them knew what micronutrients were and 36.0% of them didn't know, 25.3% of the respondents got their information on micronutrients from the questionnaire, 20.0% from friends, 17.3% from doctors, 12.7% from dietitians and 7.3% gave no response. More than half (67.3%) of the parents knew that vitamins and minerals made up micronutrients, 13.3% of them didn't know and 19.3% of them were undecided. Majority (88.7%) of the parents knew that micronutrients were important for their children while 9.3% did not know and 2.0% gave no response. Majority (86.0%) of the parents knew that micronutrients are important for brain development while 14.0% did not know. 94.0% of the parents said they would love their children to eat

micronutrient rich food while 5.3% of the parents said otherwise and 0.7% gave no response.

Table 2: Parents Knowledge of Micronutrients And Its Benefits

Indicators	Response	Frequency(N=150)	Percentage (%)
Informed on micronutrients?	Yes	123	82.0
	No	27	18.0
Have Micronutrient knowledge	Yes	95	63.3
	No	27	18.0
	Not really	27	18.0
	No response	1	0.7
Micronutrients information source	From a friend	30	20.0
	Newspaper or media	25	16.7
	Doctor	26	17.3
	Dietitian	19	12.7
	From the questionnaire	38	25.3
	Others	1	0.7
	No response	11	7.3
Vitamins and minerals make up micronutrient	Yes	101	67.3
	No	20	13.3
	Not really	29	19.3
Micronutrients gotten from food	Yes	135	90.0
	No	14	9.3
	Not really	1	0.7
Micronutrient rich food	Yes	103	68.7
	No	18	12.0
	Not really	29	19.3
Do you give your child micronutrient rich food	Yes	111	74.0
	No	10	6.7
	Not really	26	17.3
	No response	3	2.0
Micronutrients are important	Yes	133	88.7
	No	14	9.3
	No response	3	2.0
Important for brain development	Yes	129	86.0
	No	21	14.0
Love micronutrients rich food	Yes	141	94.0
	No	8	5.3
	No response	1	0.7

The feeding pattern (Table 3) of the respondents shows that 51.3% of the respondents eats thrice a day, 29.3% eats four times a day, 10.7% eats more than 4 times a day and 8.7% eats once to twice a day. Less than half (47.3%) of the respondents, snack once a day, 28.7% twice a day, 16% thrice a day, 3.3% 4 times a day, 3.3% more than 4times a day and 1.3% of the respondents don't snack at all. Majority (88.0%) of the respondents enjoyed taking snacks while 1.3% do not enjoy taking snacks and 10.7% were undecided. More than half (71.3%) of the respondents enjoyed taking fruits and vegetables, 2.0% did not, 26.7% were undecided. Slightly above half (52.0%) of the respondents take fruits and vegetables once a day, 20.0% takes twice a day, 16.7% takes it thrice a day while 7.3% of the respondents don't take fruits and vegetable and 4.0% gave no response. More than half (62.7%) of the respondents preferred junk snacks to fruits and vegetables, 36.7% did not and 0.7% gave no response.

Table 3: Feeding Pattern of Respondents.

Indicators	Range	Frequency(N=150)	Percentage (%)
Eat a day	Once	6	4.0
	Twice	7	4.7
	Thrice	77	51.3
	4 times	44	29.3
	More than 4 times	16	10.7
Snack per day	Once	71	47.3
	Twice	43	28.7
	Thrice	24	16.0
	4 times	5	3.3
	More than 4 times	5	3.3
	Never	2	1.3
Enjoy taking snacks	Yes	132	88.0
	No	2	1.3
	Not really	16	10.7
On a scale of 1-10, Snack on junk food	0	5	3.3
	1	9	6.0
	2	6	4.0
	3	6	4.0
	4	14	9.3
	5	26	17.3
	6	22	14.7
	7	26	17.3
	8	17	11.3
	9	11	7.3
	10	8	5.3
Enjoy fruits and vegetables	Yes	107	71.3
	No	3	2.0
	Not really	37	24.7
	I can't say	3	2.0
Fruits and vegetables per day	Once	78	52.0
	Twice	30	20.0
	Thrice	25	16.7
	Never	11	7.3
	No response	6	4.0
Junk snacks to fruits and vegetables	Yes	94	62.7
	No	55	36.7
	No response	1	0.7

Table 4 shows the food that contained significant amount of micronutrients among the foods that were consumed by the respondents. They include fruits like orange and apple which are rich in Vitamin C (17), Vegetables like Okro, Ewedu and Efo Egusi which are all rich in Vitamin A, Beans porridge and Moin-Moin which are rich in Vitamin A (18), Milk and yogurt rich in calcium, fortified cereal rich in B-Vitamins (19).

Table 4: Identified Food and Their Micronutrients

List Of Food	Significant Micronutrient
Efo and Egusi	Vitamin A
Apple	Vitamin C
Yogurt	Calcium
Fried Plantain	Vitamin C
Milk	Calcium
Okro	Vitamin A
Bread	Vitamin B1
Beans Porridge	Vitamin A
Ewedu	Vitamin A
Orange Juice	Vitamin C
Oat	Phosphorus
	Magnesium
Fortified Cereal	Vitamin B2
	Vitamin B12
Fish	Vitamin B3
Moin-Moin	Vitamin A

The cognitive test response results (Table 5) showed the extent of reasoning of the respondents. Almost all 97.3% passed saying '2955', 90.0% were able to say "I go to the store to buy milk" and describe a car. While lemon and sugar taste were differentiated by 78.0%. Many of the children 87.3% knows what to say when they break their friend's stuff, 84.7%) were able to add 2 additional mangoes to six, 87.3% knows the days of the week, 76.4% knows what it means to obey, 86.7% can subtract 3 from 6, 70.7% knows what to do when there is a cut on their knee, 80.7% knows the number of days in the a year 81.3% knows seconds in a minute, 74.7% knows the minutes in an hour and 72.7% knows the hours in a day but fewer percentages of the children knows what magnifying (22.7%) and vacant (30.0%) means.

Table 5: Cognitive Testing of Respondents

Table 5a: Cognitive Test Responses

Cognitive Test	Values	Frequency(N=150)	Percentage
Say 2955	Fail	4	2.7
	Pass	146	97.3
Say 'I go to the store to buy milk'	Fail	15	10.0
	Pass	135	90.0
What is a car?	Fail	15	10.0
	Pass	135	90.0
If i cut an apple into 2 halves how many do I have?	Fail	58	38.7
	Pass	92	61.3
Lemon is sour sugar is	Fail	33	22.0
	Pass	117	78.0
What should you say and do when you break your friends stuff	Fail	19	12.7
	Pass	131	87.3
Crayon and pencil different	Fail	48	32.0
	Pass	102	68.0
Crayon and a pencil alike	Fail	86	57.3
	Pass	64	42.7
What number comes before 12	Fail	9	6.0
	Pass	141	94.0
What number comes after 12	Fail	10	6.7
	Pass	140	93.3
Milk and water different	Fail	76	50.7
	Pass	74	49.3
Milk and water alike			
	Fail	83	55.3
	Pass	64	44.7
Dangerous mean	Fail	52	34.7
	Pass	98	65.3

Table 5b: Cognitive Test Responses (Cont'd).

Cognitive Test	Response	Frequency (N=150)	Percentage
Tim has 6 mangoes John gives him 2 more how many does he have	Fail	23	15.3
	Pass	127	84.7
Days in a week	Fail	19	12.7
	Pass	131	87.3
Obey mean	Fail	35	23.3
	Pass	115	76.7
Betty has 6 naira she spends 3 naira how much is left	Fail	20	13.3
	Pass	130	86.7
What should you do if you cut your knee	Fail	44	29.3
	Pass	106	70.7
Months in a year	Fail	29	19.3
	Pass	121	80.7
Magnify mean	Fail	116	77.3
	Pass	34	22.7
Seconds in a minute	Fail	28	18.7
	Pass	122	81.3
Minutes in an hour	Fail	38	25.3
	Pass	112	74.7
How many hours are in a full day	Fail	41	27.3
	Pass	109	72.7
What does vacant mean	Fail	105	70.0
	Pass	45	30.0
15 pieces of cake are divided among 5 girls how many does each girl get	Fail	37	24.7
	Pass	113	75.3

From Table 6 above 4.6% of the respondents scored an overall cognitive percentage of less than or equal to 25% which was classified as dull. 10.6% of the respondents scored between 26%-50% which was classified as not very smart, 34.7% of the respondents scored between 51%-75% which was classified as above average cognitive performance, 50% of the respondents scored a cognitive percentage of 76%-100% which was classified as highly intelligent.

Table 6: Cognitive Percentage of Respondents.

Indicators	Frequency (N=150)	Percentage
Cognitive Percentage		
15	3	2.0
20	2	1.3
25	2	1.3
30	2	1.3
35	2	1.3
40	7	4.7
45	2	1.3
50	3	2.0
55	6	4.0
60	7	4.7
65	13	8.7
70	15	10.0
75	11	7.3
80	21	14.0
85	24	16.0
90	18	12.0
95	9	6.0
100	3	2.0
Total	150	100

The respondents took 44.8% of their RDA (20) for vitamin C, 130% for vitamin B_1, 173% for vitamin B_2, 138% for B_3, 123% for vitamin B_6, 74.26% for folate and 254.17% for B_{12}. The respondents took 31.75% for calcium, 123% for phosphorous, 95.77% for sodium, 240.6% for zinc, 125.9% for iron and 117.91% for magnesium.

Table 6: Micronutrient Intake of The Respondents (N=150)

Parameter	Range	Mean ± Sd	Rda	%Rda
Vitamin A(G)	93.41 - 14062.22	3241.24 ± 4953.19	4000	
Vitamin C(Mg)	0.0 -85.73	11.20 ± 19.82	25	44.8
Vitamin B1(Mg)	0.08 - 1.71	0.78 ± 0.44	0.6	130
Vitamin B2(Mg)	0.29 - 2.24	1.04 ± 0.46	0.6	173
Vitamin B3(Mg)	0.25 – 22.37	11.04 ± 5.85	8	138
Vitamin B6(Mg)	0.06 – 1.80	0.74 ± 0.45	0.6	123
Folate (Mcg)	13.91 – 377.13	149.24 ± 87.83	200	74.62
Vitamin B12(Mcg)	0.22 – 5.66	3.05 ± 1.87	1.2	254.17
Calcium (Mg)	50.79 – 906.18	317.50 ± 225.31	1,000	31.75
Phosphorous (Mg)	116.32 – 1268.44	615.09 ± 286.38	500	123
Sodium (Mg)	137.00 – 2616.19	1149.22± 716.11	1200	95.77
Potassium (Mg)	155.42 – 1894.00	939.74 ± 414.51	3800	24.73
Zinc (Mg)	1.79- 22.79	12.03 ± 6.16	5	240.6
Iron (Mg)	3.50 – 21.73	12.59 ± 4.87	10	125.9
Magnesium (Mg)	23.67 – 991.98	153.28 ± 169.51	130	117.91

Table 8 shows the correlation between micronutrient consumption and the overall cognitive performance of the respondents, the result showed that there was no direct relationship between micronutrient consumption and overall cognitive performance of the respondents as most of their P value was negative.

Table 8: Association Between Micronutrient Consumption and Overall Cognitive Performance

Micronutrient	P-Value
Vitamin A	-0.104
Vitamin C	-0.080
Vitamin B1	-0.116
Vitamin B2	-0.052
Vitamin B3	-0.160
Vitamin B6	-0.220
Folate	-0.113
Vitamin B12	0.290
Calcium	0.100
Phosphorous	0.135
Sodium	-0.015
Potassium	-0.032
Zinc	-0.180
Iron	0.101
Magnesium	0.163

Discussion

School aged children are an important segment of any society as they represent the future generation and nutritional deprivation during school aged years can further constrain the physical and cognitive development of school aged children. Nutrition is core to brain development and, therefore, the cognitive development of children. These factors fall into two broad categories, genetic and environmental, and nutrition is a part of the biologic environment that can affect brain and cognitive development (21). Results from this study indicate that most parents of the children were educated in line with nutrition and are able to afford the nutritious meals.

The results of the assessment of micronutrient consumption of the children showed that they met up their dietary requirement for the important micronutrients for cognitive performance which, is contrary to the evidence of (1) that school aged children suffer from micronutrient deficiencies. Nutrition is likely to have a number of influences on the development of the brain. The timing of nutritional influences on the brain is also important. Scientists believe that there are critical periods of rapid brain growth and development, from gestation until the first 2 years of life during which time brain development may be particularly sensitive to insult, and deficiencies in the diet might have a particular impact. Thus, most research investigating the impact of nutrition on cognitive development has focused on effects in children under the age of 2 years (21). This study on the other hand assessed children between the ages of 5 and 10.

Appreciable levels of various micronutrients were consumed by the respondents which showed a relation to their daily consumed meals. All of the assessed micronutrients from the respondents were within range. There has been recent interest in the association between B vitamins, especially folate, and cognitive performance. Although most of the research has focused on folate and the development of the neural tube, there is some evidence that these vitamins might be important for the cognitive performance of children (22). In addition, some research has indicated that folate, B12, and B6 are important for the cognition of adults (23).

The production of thyroid hormones triiodothyronine (T3) and thyroxine (T4), both of which are essential for the growth and development of the brain, lies on the availability of iodine. Cross-sectional and randomized, controlled supplementation trials have been used to assess the effect of iodine deficiency and hypothyroidism on cognitive development in children and cross-sectional studies demonstrate that iodine deficiency has a negative effect on the cognitive performance of children while four of the seven randomized studies showed evidences of improved cognitive performance but these improvements were probably limited to those children showing improved iodine status (21).

Furthermore, results from the correlational analysis between micronutrient consumption and cognitive performance indicated that there was no direct correlation between micronutrient consumption of school aged children and cognitive performance because cognition is not solely dependent on micronutrient consumption which is in line to the research done by (4). It was reported that cognitive development is determined by a number of factors including socio-cultural and biological.

Conclusion

The consumption pattern of micronutrient rich foods by the school-aged children was as a result of their parent knowledge. The overall cognitive performance of the students gave positive results because they met up their dietary requirement for the identified micronutrient rich foods and the micronutrients recommendation responsible for cognition and psycho-social variables. However, the association between micronutrients consumption and cognitive function was negative.

Recommendation

Following the results of this research, it is recommended that:

- Parents should inculcate the habit of adequate diet consumption and be educated on the role of micronutrients on early childhood development
- School owners should help discourage excessive consumption of unhealthy snacks.

Limitation to the Research

The cognitive test questions were adopted from Slossom's intelligence test revised and this method had not been validated for use in Nigeria

Ethics approval

Ethical clearance was obtained from Babcock University Health Research Ethics Committee (BUHREC) number 677/21

Informed Consent

An informed consent was also obtained from the respondents before the questionnaire was admitted to respondents.

Declaration of interest:

The authors hereby declare no conflict of interest on this work.

Availability of data and materials

Data and materials are available on request.

Author's contribution

EO conceived, designed and supervised the research work, BT and JO did the statistical analyses, TB and OA supervised the administration of the questionnaire, BT and OB did the literature review and the first draft of the manuscript, while SH is the student who did the work and wrote the project.

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