www.ajbrui.org
Afr. J. Biomed. Res. Vol. 25 (May, 2022); 143 - 151

Research Article

Relationship Between Nutritional Status and Cognition of School-Aged Children

***Akanbi J.[1] and Fadupin G.T.[1]**

[1] *Department of Human Nutrition and Dietetics, College of Medicine, University of Ibadan. Ibadan, Nigeria*

ABSTRACT

A descriptive cross-sectional survey was conducted among 384 pupils aged 5-12 years selected from 3 public primary schools using a multi-stage sampling technique. Information on cognitive performance was collected using Raven's Standard Progressive Matrices. Food Frequency Questionnaire and 24-hour dietary recall were used to obtain dietary information while anthropometric data were sourced using weighing scales and height meters. The mean age of the respondents was 9.0 ± 1.8 years. The mean weight and height were 23.4±4.6kg and 1.25±0.1m respectively. 1.6% of the respondents had normal height-for-age (>1 SD), 92.7% were moderately stunted (-2 to -3 SD) and 5.7% were severely stunted (<-3SD). The Standard Progressive Matrices showed that primary 5 and primary 4 pupils had the highest and lowest mean cognition score of 24.5 and 19.4 respectively. Positive correlation was observed between weight of pupils and intake of Carbohydrate (0.228), Protein (0.142), Fiber (0.157), Folate (0.232), Iron (0.254) and Zinc (0.125). Similarly, a significant correlation was also observed between vitamin A intake and Set B cognition scores. Height-for-age and BMI-for-age did not have a significant effect on cognition as shown in the study. However, the correlation coefficient of (r=0.108; p<0.005) reveals that there is a weak but significant relationship between weight and Total Cognition Score (TCS). These findings suggest that Weight-for-height is a better anthropometric index for assessing the relationship between nutritional status and cognition among school-aged children. Also, consumption of vitamin A-rich foods should be encouraged for cognitive development in the school age.

Keywords: *Raven's Standard Progressive Matrices, Cognition, Nutritional status, school-aged children.*

*Author for correspondence: Email: akanbij0@gmail.com; *Tel: +234 816 436 4790*

Received: December 2021; Accepted: February 2022

DOI: https://dx.doi.org/10.4314/ajbr.v25i2.5

INTRODUCTION

Adequate brain function is a prerequisite for efficient cognition and the performance of organized behaviour. Indeed, the uninterrupted activity of the brain is of vital importance to the survival of the organism since it ensures the continuous performance of many essential voluntary and involuntary functions. It is therefore imperative that the brain is protected from even short-term disruptions of its efficient working conditions. One crucial factor is the supply of metabolic fuel to the brain, in the form of glucose. Glucose supply to the brain is maintained by complex mechanisms involving several hormones and feedback loops to ensure that glycaemia is regulated and maintained at appropriate levels at all times. Given the existence of such potent biological safeguard mechanisms, mental activity that allows cognitive appreciation of the world and appropriate behavioural responses to environmental conditions should be protected from moment-to-moment fluctuations in nutritional status from one meal to the next, and, more generally, from variations in nutrient availability under a broad range of life situations, as long as major nutritional or energy insufficiencies do not occur.

Nevertheless, many studies suggest that poor nutritional status can indeed adversely affect brain function and impact on cognition and behaviour. To a certain extent, appropriate correction of nutrient deficiencies can indeed lead to measurable improvement. Moreover, recent findings suggest that, even in situations of adequate nutritional status, the brain can actually be sensitive to short-term variation of glucose availability. Studies in resource-poor settings have examined the relation between nutrition and child development, many of which indicate that poor diet and nutritional status are associated with development (Aboud and Yousafzai, 2015; Iannotti *et al*., 2016).

Piecemeal evidence supports this model, showing that children living in healthy environments are taller, have fewer illnesses, and are more likely to explore their environment through enhanced motor skills and activity; growth and exploration are positively associated with mental development (McCoy, 2016; Aburto, *et al*., 2010; Larson and Yousafzai 2017; MacIntyre, McTaggart, *et al*., 2014). Offering primary school children the right food choices and helping them develop positive and healthy eating habits will support optimal functioning of the brain (Ajuzie *et al*., 2018). Dietary practices that influence the nutritional status of school-aged children are more likely to impact on their school performance (Kubik *et al*., 2003).

The prevalence of malnutrition is still high in Nigeria (52.7%) (Goon *et al*., 2011). Many children are malnourished which prevent them from reaching their optimum potential, because nutrition is a foundation on which human progress in built (ACC/SCN, 2000; Veneman, 2011). It is however sad that malnutrition has continued to be a public health problem in developing countries where poor socio-economic conditions has continued to work in synergy with malnutrition (Olusanya *et al*., 2010).

This study was carried out to assess the existent relationship between nutritional status and cognition of school-age children using the instrumentality of the Raven's Standard Progressive Matrices and other nutritional status indices.

MATERIALS AND METHODS

Design: This is an institution-based, descriptive, cross-sectional study conducted between January and March 2020 using three purposively selected public primary schools from three (3) local government areas in Ibadan metropolis – Ibadan North, Ibadan North East and Egbeda.

Sampling: 420 school-age children participated in the research. They were selected from three public primary schools in Ibadan metropolis (Abadina Primary School, Tose Primary School and Ayepe Primary School) using the multi-stage sampling method. From the first two schools, 130 pupils will be selected from across primary 1 to 5 (i.e., 26 pupils from each class) while 160 pupils will be selected from the third school (32 pupils per class) using the systematic random sampling method with the aid of the class register which will also help to control for the age of the school-age children. Due to data cleaning, 385 respondents were eventually used for statistical analysis. Pre-selected pupils who were absent on the data collection day were substituted by other eligible pupils from the same classroom.

Data Collection: Data on socio-demographic, anthropometric and dietary characteristics of the respondents were collected using purpose-tailored, structured questionnaires. The cognitive function of the school children was assessed using the Standard Progressive Matrices (Sets A and B)

Socio-Demographic Characteristics: Socio-demographic information collected include gender, age, ethnicity, level of education and type of employment of parents.

Anthropometric Characteristics: Anthropometric characteristics assessed include weight, height, and Mid-Upper Arm Circumference (MUAC). Body weight was recorded to the nearest 0.5 kg using the HANA weighing scale (among others). Instruments were regularly checked for accuracy. Calibration of the indicator against zero reading was often checked before weighing. Children were weighed with light clothing and without shoes. Height was measured using the improvised calibrated wall, without shoes in a standing position.

Dietary Intake: The 24-hour dietary recall was used to collect information on all food and drink intake of the school children within the last 24 hours preceding the interview. Interviewers were trained on how to effectively elicit truthful responses from the respondent especially with the use of open-ended questions. The information collected was later analyzed using the ESHA Total Diet Assessment (TDA) software.
Food Frequency Questionnaire (FFQ), validated for the Nigerian population was used to obtain quantitative (frequency) information about the dietary intake of the school children. Foods were grouped into seven namely, cereals and grains, snacks, root and tubers, legumes, animal products, vegetables and fruits.

Cognitive Function: The cognitive ability of the school age children was assessed using the Standard Progressive Matrices (Sets A and B), a well-validated measure of basic cognitive functioning for different cultural, ethnic, and socio-economic groups (Raven, 2000). The cognitive tests were administered by semi-trained data collectors.
Raven *et al*. (1983), describe the Matrices scales as tests of observation and clear thinking, with the order in which the problems are presented providing · the standard training in the method of working. As a measure of basic cognitive aptitude as well as representability, only sets A and B were used for this study. Raven *et al*. (1983) partially justified this approach, noting the increasing order in the difficulty of the cognitive test from Set A to E which "makes the understanding of the initial items crucial. The first and second sets in the scale, and the introductory problems of the third and fourth sets provide, for the adult, little more than training in the method of thinking"

Administering the cognition test: The tester, usually, was introduced to the class to be tested, by a member of staff at the school after which the tester then introduced himself or herself to the class. The languages spoken English, Yoruba and Hausa as the case demanded. This was done so that a good rapport between the tester and testees could be established. The intention was to breakdown the authoritative status that testers usually have. The reason for the testing was explained. Pupils were told to fill in their names on the test materials (set A and B) for proper organization and to prevent mismatches during data entry. All the above was carried out for ethical reasons, and also to reduce the anxiety experienced by testees at the time of testing.

The trained testers, sometimes in collaboration with class teachers, provided necessary instructions to the respondents on how to answer the test questions. The illustration was made with Items Al and B1 and was sometimes drawn on the board for a graphic representation. The trained testers fielded questions from the pupils. After the instructions, were delivered orally, the tester asked the students to work through the test at their own pace, and when finished to please indicate.

The test workbooks were then collected and collated and placed in an envelope.

The scoring: The test was scored by awarding one point for every correct answer and no point for a wrong answer. From this a total score out of a possible 60 was obtained as was used by Raven *et al*. (1983) however, for this study, only two sets (A and B) were used. This earns the testee a total score out of a possible 24 (12 questions per set). After this, 2.5 was used a conversion factor to finally obtain a total score out of 60.

Table 1:
Cognition Grading System Used for Study

Grade	Label	Score Range	Description
GRADE I	"Intellectually superior"	55 and above	If score lies at or above the 95th percentile for people of the same age group.
GRADE II	"Definitely above the average in intellectual capacity"	45 – 54	If score lies at or above the 75th percentile; II+ if score lies at or above the 90th percentile.
GRADE III	"Intellectually average"	30 – 44	If score lies between the 25th and 75th percentiles; III+, if score is greater than the median or 50th percentile; III-, if score is less than the median.
GRADE IV	"Definitely below average in intellectual capacity"	11 – 29	If score lies at or below the 25th percentiles; IV-, if score lies at or below the 10th percentile.
GRADE V	"Intellectually defective"	10 and below	If score lies at or below the 5th percentile for his age group.

Raven *et al.*, 1983, p. SPM17-SPM18

Data Analysis: Independent sample t-test and one-way ANOVA were used to compare mean differences in cognitive test scores. Chi square-test was used to test for associations between variables on the basis of frequencies. Pearson correlation was used to check the relationship between nutritional status and cognitive performance. Stepwise, multivariate and bivariate logistic regression analyses were performed to identify the associated factors with cognition scores (dependent variable).

The dependent variable (cognition score) was categorized to allow for test of relationship with nutritional status (height-for-age, weight-for-age, and Body Mass Index-for-age Z scores). Crosstabulation was also carried out to assess the interrelationship between the categorized cognition outcomes and nutritional status. Histograms were used to check for the normality of continuous data. Statistical Package for Social Sciences (SPSS) version 20 was used with level of significance at 5%. Nutrient intake data obtained through the 24-hour diet recall was analyzed using adapted Total Dietary assessment (TDA) software.

RESULTS

Sociodemographic Characteristics: Table 2 indicates that participants' ages ranged between 5 and 12 with the male respondents (53.5%) outnumbering the female counterpart (46.5%). All classes in the primary school were included in the study with primary 5 having the highest number of respondents (21.3%). Christianity (47.3%), Islam (52.5%) and Traditional African (0.3%) were the religions represented in the study. Respondents from the Yoruba ethnic group had the highest percentage of 87.8.

Artisanship (46.2%) and trading (53.5%) were the occupations with the highest frequencies (fathers' occupation and mothers' occupation respectively), with unemployed fathers (0.3%) and mothers with 'other' occupations (2.1%) as the lowest. Majority of fathers and mothers had only secondary school education (49.4% and 44.7% respectively).

Anthropometric Indices: Shown in Table 3, 1.6% of the respondents had normal height-for-age zed score (>1 SD), 92.7% were moderately stunted (-2 to -3SD) and 5.7% were severely stunted (<-3SD). 90.6% of respondents had normal BMI-for-age (-2 to +1SD), 7.3% were thin (<2SD) while 1.6% were obese. Also, study reveals majority (73%) of the pupils were moderately underweight, 4.2% were severely underweight and 22.9% had invalid data because they were above 10 years of age (further explained under Table 3).

Food Consumption Frequency: Of all staple foods investigated, Table 4 shows that biscuit, with 23.1%, rice, with 61.3%, groundnut, with 45.2%, milk, with 31.7% and wheat with 74.5%, had the highest daily, regular (3-6 times a week), occasional (2 times a week), rare (once a week) and null consumption respectively.

Nutrient Adequacy: The average daily intake of the pupils is reported as obtained from the 24-hour diet recall. Table 5 shows the adequacy levels of the nutrients of concern. 95.1% of the respondents had adequate protein intake of which 43.1% and 51.9% were females and males respectively. 93% had adequate carbohydrate intake of which 43.1% and 49.9% were females and males respectively. Majority (83.3%) of the pupils had inadequate fat intake (as a percentage of total energy). As for micronutrients more respondents had adequate vitamin A and vitamin B12 intake (69.6% and 56.6% respectively) while majority (61%) had adequate folate intake. Also, 79% and 70.6% of respondents had adequate had adequate iron and zinc intakes.

Cognition Scores: Table 6 reveals that mean cognition scores across the five classes were higher for set A compared to set B. In addition, male pupils had higher mean cognition scores for set A than had their female counterpart except in primary 2 where the mean scores were 5.37 and 5.53 for boys and girls respectively. In contrast, females had higher mean cognition scores across the five classes compared to the males for set B. Overall, i.e., out of 60, primary 5 and primary 4 pupils had the highest and lowest mean cognition score of 24.5 and 19.4 respectively.

Table 2:
Socio-Demographic Characteristics of Respondents

Characteristics		Frequency	Percentage
Gender	Male	206	53.5
	Female	179	46.5
Age	5	6	1.6
	6	41	10.6
	7	43	11.2
	8	68	17.7
	9	48	12.5
	10	91	23.6
	11	45	11.7
	12	43	11.2
Class	Primary 1	73	19.0
	Primary 2	78	20.3
	Primary 3	75	19.5
	Primary 4	77	20.0
	Primary 5	82	21.3
Religion	Christianity	182	47.3
	Islam	202	52.5
	Traditional	1	0.3
Ethnicity	Yoruba	338	87.8
	Igbo	30	7.8
	Hausa	5	1.3
	Others	12	3.1
Father's occupation	Trading	63	16.4
	Artisanship	178	46.2
	Civil service	46	11.9
	Farming	22	5.7
	No response	14	3.6
	Unemployed	1	0.3
	Other	61	15.8
Mother's occupation	Trading	206	53.5
	Artisanship	117	30.4
	Civil service	16	4.2
	Farming	10	2.6
	No response	19	4.9
	Unemployed	9	2.3
	Other	8	2.1
Father's Educational level	No formal education	8	2.1
	Primary education	43	11.2
	Secondary education	190	49.4
	Tertiary education	35	9.1
	No response	109	28.3
Mother's Educational level	No formal education	13	3.4
	Primary education	57	14.8
	Secondary education	172	44.7
	Tertiary education	27	7
	No response	116	30.1

Table 3:
Anthropometric Indices of Respondents

Indices	Frequency	Percentage
Height-for-Age		
Normal Height-for-age (>-1SD)	6	1.6
Moderate stunting (-2 to -3SD)	357	92.7
Severe stunting (<-3SD)	22	5.7
BMI-for-Age		
Normal Weight (-2 to +1 SD)	349	90.6
Thinness (< -2SD)	28	7.3
Obesity (> 2SD)	6	1.6
Missing	2	0.5
Weight-for-Age		
Moderate underweight	281	73
Severe underweight	16	4.2
Invalid data*	88	22.9

**The weight-for-age curves enables countries that routinely measure only weight to monitor growth throughout childhood. In older children, i.e., above 10 years, weight-for-age is not a good indicator as it cannot distinguish between height and body mass in an age period where many children are experiencing the pubertal growth spurt and may appear as having excess weight (by weight-for-age) when in fact they are just tall. BMI-for-age is the recommended indicator for assessing thinness, overweight and obesity in children 10-19 years (WHO, 2009).*

Intelligence Quotient Rating: As shown in table 7, majority (75.6%) of the pupils are "definitely below average in intellectual capacity", 12.2% are "intellectually average", 10.4% are "intellectually defective", 1.6% are "definitely above the average in intellectual capacity" while just 0.3% are "intellectually superior"

Cognition and Nutrient Intake: The level and type of correlation between Total Cognition Score, being the dependent variable, and nutrient intake – the independent variable is shown in table 8. There is a weak correlation, both positive and negative, between cognition and nutrient intake. The only significant relationship discovered was between vitamin A and set B cognition score with a correlation of -0.101 ($p<0.05$).

Cognition, Age and Anthropometry: Study reveals that there is significant positive correlation between set A cognition scores and weight (0.148, $p<0.01$), set A cognition score and age (0.108, $p<0.05$) and between total cognition score and weight (0.108, $p<0.05$). This is shown in Table 9.

Anthropometric Status and Nutrient Intake of Respondents: Table 10 shows that there is positive correlation between weight of pupils and intake of carbohydrate (0.228, $p<0.01$), protein (0.142, $p<0.01$), fiber (0.157, $p<0.01$), folate (0.232, $p<0.01$), iron (0.254, $p<0.01$) and zinc (0.125, $p<0.05$). There was no significant correlation between height-for-age and nutrient intake as well as between BMI-for-age and nutrient intake.

DISCUSSION

This study brought to fore the pivotal role that nutrition plays in cognitive development most especially among school children. The socio-demographic characteristics of this study is not off the trend especially in a geographical setting like Ibadan, Oyo state. The distribution pattern of respondents' characteristics – age, class, religion, ethnicity, occupation and education – are typical. Similar to the findings of Haile *et al*., (2016) and Perignon *et al*., (2014), male respondents outnumbered their female counterpart in this study. However, this is not in tandem with the body of research (Ghosh *et al*., 2016 and Kamath *et al*., 2017) that reveals increasing female enrolment in education as more than half of the participants were males.

The mean age for the study was 9 years (9.0 ± 1.8). This is very similar to the findings of Ayalew *et al*., (2016), Perignon *et al*., (2014), and Adedeji *et al*., (2017) where the mean ages of respondents were 9.45 ± 1.97, 9.66 ± 2.3 and 9.3±1.8 respectively. The trend of the frequency distribution of respondents' age in this study witnessed pupils, ten (10) years of age, with the highest percentage. This connotes that there is most likely late school enrolment and delayed onset of primary education.

Table 4:
Food Consumption Frequency of the Respondents

	Food Item	**Never**		**Rarely (1x/ wk)**		**Occasionally (2x/wk)**		**Regularly (3-6x/wk)**		**Daily**	
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Cereals and Grains	Rice	5	1.3	13	3.4	43	11.2	236	61.3	88	22.9
	Boiled Maize	234	60.8	42	10.9	60	15.6	48	12.5	1	0.3
	Wheat	287	74.5	52	13.5	31	8.1	11	2.9	4	1
	Bread	37	9.6	60	15.6	136	35.3	107	27.8	45	11.7
Snacks	Flour product	59	15.3	52	13.5	77	20	130	33.8	67	17.4
	Biscuit	27	7	28	7.3	75	19.5	166	43.1	89	23.1
Root and tubers	Garri	34	8.8	40	10.4	84	21.8	158	41	69	17.9
	Fufu	123	31.9	89	23.1	88	22.9	72	18.7	13	3.4
	Yam (boiled)	92	23.9	93	24.2	107	27.8	76	19.7	17	4.4
	Amala	60	15.6	38	9.9	102	26.5	135	35.1	50	13
	Sweet potato (boiled)	193	50.1	67	17.4	68	17.7	44	11.4	13	3.4
Legumes	Beans (boiled)	38	9.9	82	21.3	130	33.8	121	31.4	14	3.6
	Groundnut	36	9.4	51	13.2	174	45.2	101	26.2	23	6
Animal products	Beef	63	16.4	52	13.5	121	31.4	131	34	18	4.7
	Chicken	196	50.9	92	23.9	40	10.4	48	12.5	9	2.3
	Fish	20	5.2	40	10.4	126	32.7	163	42.3	36	9.4
	Milk	86	22.3	122	31.7	76	19.7	82	21.3	19	4.9
Vegetables	Ewedu	54	14	63	16.4	97	25.2	138	35.8	33	8.6
	Spinach (Efo)	80	20.8	78	20.3	104	27	112	29.1	11	2.9
	Pumpkin (Ugu)	239	62.1	61	15.8	44	11.4	38	9.9	3	0.8
	Okra	147	38.2	77	20	89	23.1	60	15.6	12	3.1
Fruits	Orange	130	33.8	92	23.9	70	18.2	75	19.5	18	4.7
	Pineapple	187	48.6	107	27.8	52	13.5	34	8.8	5	1.3
	Banana	118	30.6	94	24.4	105	27.3	56	14.5	12	3.1
	Watermelon	190	49.4	100	26	48	12.5	41	10.6	6	1.6

Table 6:
Mean Cognition Scores of the Respondents According to Classes

Class	**Number of Pupils**	**Mean Age (SD)**	**Set A /12 Mean (SD)**			**Set B / 12 Mean (SD)**			**TOTAL / 60 Mean (SD)**		
			Males	**Females**	**Total**	**Males**	**Females**	**Total**	**Males**	**Females**	**Total**
Primary 1	73	6.66 (0.9)	5.46 (2.4)	4.74 (2.7)	5.12(2.5)	2.97 (2.4)	4.35 (3.9)	3.62 (3.2)	0	60	21.8 (9.9)
Primary 2	78	8.03 (1.3)	5.37 (1.9)	5.53 (2.3)	5.44(2.0)	3.22 (0.98	2.97 (1.3)	3.12 (1.1)	7.5	35	21.4 (5.6)
Primary 3	75	9.08 (1.2)	5.77 (2.3)	5.2 (2.4)	5.47(2.3)	2.77 (0.9)	2.85 (1.3)	2.81 (1.1)	5	32.5	20.7 (6.5)
Primary 4	77	10.35(1.1)	5.79 (2.9)	4.03 (2.7)	5.01(2.9)	2.72 (1.5)	2.82 (1.3)	2.77 (1.4)	0	45	19.4 (9.0)
Primary 5	82	10.78 (1)	6.3 (2.4)	6.15 (2.3)	6.23(2.3)	3.44 (1.7)	3.67 (2.5)	3.55 (2.1)	5	50	24.5 (8.9)

Table 5:
Nutrient Adequacy Level of Respondents

	RDA*			Mean ±SD			Adequate N (%) All age groups			Inadequate N (%) All age groups		
Age (years)	**4-8**	**9-13**		**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
Macronutrient		Male	Female									
Fat (g/day)	-	-	-	27.2 ±17.5	24.5 ±14.8	25.9 ±16.4			-			-
Protein (g/kg BW/day)	0.7	0.7	0.7	54.5 ±25.3	51.5 ±27.0	53.1 ±26.1	200 (51.9)	166 (43.1)	366 (95.1)	6 (1.6)	13 (3.4)	19 (4.9)
Total fibre (g/day)	-	-	-	6.3 ±4.6	6.0 ±4.5	6.1 ±4.6			0 (0.0)			383 (100.0)
Carbohydrate (g/day)	100	100	100	232.6 ±97.7	210.6 ±92.7	222.4 ±95.9	192 (49.9)	166 (43.1)	358 (93)	14 (3.6)	13 (3.4)	27 (7)
As % of total energy												
Total fat (%)	25-35	25-35	25-35	19.06 ±0.06	19.06 ±0.06	19.06 ±0.06			61 (15.9)			319 (83.3)
Protein (%)	10-30	10-30	10-30	13.00±0.03	13.00 ±0.03	13.00 ±0.03			308 (80.4)			75 (19.5)
Carbohydrate (%)	45-65	45-65	45-65	68.20 ±0.06	68.20 ±0.06	68.20 ±0.06			118 (30.8)			0 (0.0)
Vitamins												
Vitamin A (µg RE/day)	400	600	600	4835.0 ±4669.1	3426.4 ±3751.4	4180.1 ±4319.3	146 (37.9)	122 (31.7)	268 (69.6)	60 (15.6)	57 (14.8)	117 (30.4)
Vitamin B_{12} (µg/day)	1.2	1.8	1.8	2.0±1.8	2.0±1.7	2.0±1.8	117 (30.4)	101 (26.2)	218 (56.6)	89 (23.1)	78 (20.3)	167 (43.4)
Folate (µg/day)	200	300	300	263.2 ±164.6	239.6 ±159.8	252.2 ±162.6	85 (22.1)	65 (16.9)	150 (39)	121 (31.4)	114 (29.6)	235 (61)
Minerals												
Iron (mg/day)	10	8	8	13.9 ±5.6	12.6 ±5.3	13.3 ±5.5	175 (45.5)	129 (33.5)	304(79)	31 (8.1)	50 (13)	81 (21)
Zinc (mg/day)	5	8	8	9.9 ±4.5	9.4 ±4.2	9.7 ±4.4	150 (39)	122 (31.7)	272 (70.6)	56 (14.5)	57 (14.8)	113 (29.4)

* Linus Pauling Institute, Oregon State University

Table 7:
Intelligence Quotient Rating of the Respondents

Scale category	MALE		FEMALE		Total	
	Frequency	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
"Intellectually superior"	0	0	1	0.6	1	0.3
"Definitely above the average in intellectual capacity"	2	1.0	4	2.2	6	1.6
"Intellectually average"	24	11.7	23	12.8	47	12.2
"Definitely below average in intellectual capacity"	163	79.1	128	71.5	291	75.6
"Intellectually defective"	17	8.3	23	12.8	40	10.4

Table 8:
Correlation Analysis of Total Cognition Score and Nutrient Intake

	Carbohydrate	Protein	Fat	Poly Unsaturated Fat	Fiber	Vitamin A	Vitamin B12	Folate	Iron	Zinc
Set A	.025	-.006	-.048	-.038	-.036	.047	-.053	-.038	.006	-.023
Set B	.047	-.038	-.026	-.036	-.012	-.101*	-.049	-.015	.022	-.010
Total Cognition Score	0.047	-0.028	-0.051	-0.049	-0.033	-0.025	-0.069	-0.037	0.018	-0.023

***.** Correlation is significant at the 0.05 level (2-tailed).

Table 9:
Correlation Analysis of Total Cognition Score, Age and Anthropometry

	Age	Weight	Height-for-age	BMI-for-age
Total Cognition Score	0.069	0.108*	0.025	0.031
Set A	0.108*	0.148**	-0.017	0.059
Set B	-0.021	-0.003	0.064	-0.021

. Correlation is significant at the 0.05 level (2-tailed).* *. Correlation is significant at the 0.01 level (2-tailed).*

Table 10:
Correlation Coefficients of The Relationship Between Anthropometric Status and Nutrient Intake

	Carbohydrate	Protein	Fat	Poly Unsaturated Fat	Fiber	Vitamin A	Vitamin B12	Folate	Iron	Zinc
Weight	0.228**	.142**	.062	.043	.157**	.021	.032	.232**	.254**	.125*
Height-for-age	-.048	-.013	-.085	-.066	.001	-.009	-.008	.013	-.035	-.010
BMI-for-age	-.043	-.015	-.053	-.064	-.046	-.053	-.049	-.042	-.046	-.048

*****.*** *Correlation is significant at the 0.01 level (2-tailed).* **. Correlation is significant at the 0.05 level (2-tailed).*

The highest educational achievement of majority of parents was secondary education. Only very few were able to obtain tertiary education (9.1% for fathers and 7% for mothers). This is most likely as a result of lack of financial support and has its toll on the academic performance of the school children. Buttressing the foregoing is a study conducted in Orang Asli village of Malaysia by Murtaza *et al*., (2019).

The study showed that a father's years of education and home environment, specifically the availability of learning materials at home and the responsiveness of the parent to the child, consistently appeared as the significant predictors for all three cognitive indices (Working Memory Index, Processing Speed Index, and Cognitive Proficiency Index) for the children. It is noteworthy that majority of the pupils, probably due to young age, do not know the educational level unlike the occupation of their parents. This is a form of limitation for the study.

The minimum age from the study was five (5) which is the age at which middle childhood begins and eventually ends at ten (10). The oldest participant in the study was 12 years of age. This age range (5-12), was also used by Ghosh *et al*, (2016) in a study examining the factors associated with the development of motor proficiency in school children of Kolkata. The average age of boys (9.2 ± 1.9) was higher than that of girls (8.9 ± 1.7) as was also observed from the study carried out by Perignon *et al*. (2014) where the average age of boys and girls were 9.75 ± 2.34 and 9.54 ± 2.17 respectively. This is possibly because there is a higher rate of late school enrolment among boys than girls. This could also be attributed to the fact that more boys were randomly selected for the study than were girls. Overall, the average age was 9 years

Stunting is evidence of chronic malnutrition. A very large percentage (92.7%) of the school-age children were moderately stunted (-2 to -3SD) but had a normal BMI-for-age (90.6%). This finding is in tandem with that of Perignon *et al*. (2014) where stunting was a high-risk factor for lower scores in all tests after controlling for age, gender and micronutrient status (iron, vitamin A, zinc, iodine), and also for socio-economic status in the sub-sample of children. Perignon *et al*. (2014) also discovered that the prevalence of stunting, both moderate and severe, was higher in children greater than 10 years than in children less than 10 years.

For stunting, there is a fair contrast between the findings from this study and that of Murtaza *et al*., (2019) where the lesser percentage (35.6%) of respondents were stunted but majority (84.8%) had normal Body Mass Index for age. Weight-for-age was not included in majority of the statistical analysis because above 10 years, it is not a good indicator as it cannot distinguish between height and body mass in an age period where many children are experiencing the pubertal growth spurt and may appear as having excess weight (by weight-for-age) when in fact they are just tall (WHO, 2009).

Biscuit, with 23.1%, was the food with the highest daily consumption in the study. This is because it is what majority of the pupils purchase on their way to school, during break period and even on their way back home. Also, biscuit is a common gift item that school-age children receive from older acquaintances. This is also a pointer to the increasing rate of junk consumption among children in this age group.

Rice, being a staple food in this part of the world, was the food with the highest (61.3%) regular consumption (3-6 times a week). This is largely reflective of the high preference that school-age children have for rice which also doubles as a staple food in this part of the world. In striking contrast, Wheat had the highest percentage (74.5%) of non-consumption in the week prior to the research. This further reveals the anatomy of school-age children's food preferences and choices.

There was a high rate of protein adequacy (95.1%) from the study most likely due to the fact that there was also a fairly-high rate of consumption of protein food sources such as beef (31% - regular consumption) and fish (42.3% - regular consumption) as revealed from the food frequency consumption table. Plant protein sources such as groundnut and beans were also fairly consumed. Unfortunately, this did not reflect in the height-for-age outcome of the respondents as majority were moderately stunted. This lack of correlation may be due to the fact that the protein adequacy observed was just momentary and not representative of their long-term dietary intake status.

Carbohydrate adequacy level was likewise high (93%) owing to the fact the staple foods in this part of the world, such as rice and maize, are mainly rich sources of carbohydrate consumed on an average of two times per week but on the other hand, fat inadequacy (83.3%), as seen in this study, was high probably as a result of overconsumption of lean sources of fat such as lean meat, lean fish and skimmed milk. Assessed as a percentage of total energy intake, fat is a key player in the cognitive performance of the school age. According to Bryan *et al*., 2004. The integrity of the Central Nervous System has been associated with Omega-3 PUFAs in particular, and also with two of the longer-chain Omega-3 fatty acids—eicosapentaenoic acid (EPA, 20:5) and docosahexaenoic acid (DHA, 22:6)—which seem to be the most beneficial to the CNS.

Carbohydrate and protein adequacy findings from this study are in contrast with those of Ajuzie *et al*. (2018) where the nutritional status and school performance of primary school children were assessed in Ogun State, Nigeria. Ajuzie *et al*. (2018) discovered that the carbohydrate intake of more than half of respondents (54.3%) was inadequate, 39.8% had adequate intake and 5.9% had excess intake. For Protein, 80.0% was inadequate, 17.3% adequate while 2.8% of the school-age children had excess intake. However, there is similarity between the findings of Ajuzie *et al*. (2018) and that of this study as regards fat adequacy – the larger percentage of respondents had inadequate fat intake in both studies.

Cognition micronutrient adequacy levels were also assessed in this study. Findings show that Vitamin A, Vitamin B12, Iron and Zinc adequacy levels were high (69.6%, 56.6%, 79% and 70.6% respectively) while that of folate was low (39%). In close comparison with previous studies such as that of Ajuzie *et al*. (2018), there is observed difference in the adequacy level of vitamin A and zinc. In this study, a larger percentage of the respondents had adequate consumption vitamin A and zinc while reverse was the case in the previous study examined. This is possibly due to the abundance of foods rich in these nutrients in Oyo state as compared to Ogun state.

Mean cognition scores across the five classes were higher for set A compared to set B. This is owing to the fact that Standard Progressive Matrices, from set A to E, are arranged in order of increasing difficulty with set A being the least difficult and set E the most difficult. Set A, uses the principle of completing a pattern in a continuous figure while Set B uses the principle of a figural analogy in a two-by-two matrix (Vass, 1992).

Male pupils had higher mean cognition scores for set A than had their female counterparts while females had higher mean scores for set B than the males. This possibly suggests an effect of gender on cognition.

Overall, pupils from primary 5 had the highest mean cognition score. This is as expected owing to the fact that there is significant positive correlation between age and set A cognition score. The foregoing does not apply to pupils from primary 4 who had the lowest mean cognition score even though there was not much difference in the mean ages of both classes.

Majority (75.6%) of the respondents were "definitely below average in intellectual capacity" according to the standard progressive matrices categorization with their scores lying at or below the 25th percentile (i.e., between 11 and 29 marks out of a total of 60). Reason for this is not far-fetched as folate adequacy level is lower than folate inadequacy level across all the Intelligence Quotient level categories but one.

Folate is an important micronutrient necessary for the cognitive function of the school-age. Cross-sectional studies suggest that low folate intake and/or status is positively associated with cognitive performance, especially memory performance, either alone or in combination with low B12 (Bell *et al*., 1990; Goodwin *et al*., 1983; Hassing *et al*., 1999; Wahlin *et al*., 1996). The poor cognition distribution reflected in this study is also probably attributed to the geographical setting in which the respondents live as children in urban settings will be expected to yield better cognition outcomes.

Findings on the statistical relationship between cognition and anthropometry reveal the existence of correlation between Total Cognition Score and weight as well as between set A cognition score and weight. This suggests that there is a significant association between how much a school-age child weighs and his/her cognitive ability i.e., the higher the weight of a school-age the better the cognition outcome. In the same vein, this study reveals the existence of a significant relationship between weight and macronutrients such as carbohydrate, protein and fiber as well as with micronutrients like folate, iron and zinc intakes suggesting that nutrient intake has impact on the weight of the school-age children which in turn impacts cognitive ability.

In conclusion, majority of the variables such as height-for-age and BMI-for-age that were assessed did not have a significant effect on cognition of the children. However, body weight, via adequate consumption of nutrients, better impacts cognition. Therefore, the study strongly suggests that weight-for-height as an anthropometric index should have positive influence on the cognitive function of the school age. More so, this index was not employed in this current study making it a justification for future research. Finally, Vitamin A and flour products (e.g., biscuit) were also implicated in this study as seen to positively impact cognitive function among school-age children, creating a possible link between the vitamin A fortification of flour and mental health. This finding should also gender further studies. This study had its own limitations. The first limitation was the small sample size and includes children mostly from urban area where malnutrition is not distributed widely as rural. The nutrient analysis software used for the study did not assess some cognition micronutrients, example is Iodine, which is also a determinant in cognitive development. Also, this study, due to contingencies, did not use a more elaborate cognition rating scale such as the Weschler Intelligence Scale for measuring the different dimension of cognitive function. In addition to that, not all the sets of the Raven's Standard Progressive Matrices were employed. The measurement tools utilized to capture diet (food frequency questionnaires and a single 24-hour recall) may not have accurately capture typical dietary intake. In addition, it is possible that children may be spending a large portion of their time in a preschool setting which exposed them to a different food environment. Working with school-age children comes with its own limitations as well, especially regarding the reliability of information that is supplied. The small sample size used for this study was also a limitation since the larger the sample size the smaller the Sampling Error and the greater the Confidence Interval.

REFERENCES

4th Report on the world nutrition situation. (2000). Nutrition throughout the life cycle. United Nations Administrative Committee on Nutrition (ACC/SCN) in collaboration with International Food Policy Research Institute (IFPRI);4-12.

Aboud, F.E., Yousafzai, A.K. (2015). Global health and development in early childhood. Annu Rev Psychol 66:433–57.

Aburto NJ, Ramirez-Zea M, Neufeld LM, Flores-Ayala R. (2010) The effect of nutritional supplementation on physical activity and exploratory behaviour of Mexican infants aged 8–12 months. Eur J Clin Nutr 64:644–51.

Adedeji, I. A., John, C., Okolo, S. N., Ebonyi, A. O., Abdu, H., and Bashir, M. F. (2017). Malnutrition and the Intelligence Quotient of Primary School Pupils in Jos, Nigeria. British Journal of Medicine and Medical Research 21(2): 1-13, 2017; Article no. BJMMR.32504 ISSN: 2231-0614, NLM ID: 101570965.

Ajuzie, N. C., Sanusi, R. A., and Makinde Y. O. (2018). Nutritional Status and School Performance of Primary School Children in Ogun State, Nigeria. Journal of Nutritional Health and Food Science. 6(6):1-7. DOI: 10.15226/jnhfs.2018.0011

Ayalew, M., Bayray, A., Bekele A., and Handebo, S. (2020) Nutritional Status and Educational Performance of School-Aged Children in Lalibela Town Primary Schools, Northern Ethiopia. International Journal of Pediatrics Volume 2020, Article ID 5956732, https://doi.org/10.1155/2020/5956732

Bell IR, Edman JS, Marby DW, *et al*. (1990). Vitamin B12 and folate status in acute geropsychiatric inpatients: affective and cognitive characteristics of a vitamin nondeficient population. Biol Psychiatry.;27:125–137.

Bryan J., Osendarp S., Hughes D., Calvaresi E., Baghurst K., and Klinken J. (2004). Nutrients for Cognitive Development in School-aged Children. Nutrition Reviews, Vol. 62, No. 8

Ghosh S., Ghosh T., Chowdhury S. D., Wrotniak B. H., Chandra A. M. (2016). Factors Associated with the Development of Motor Proficiency in School Children of Kolkata: A Cross-Sectional Study to Assess the Role of Chronic Nutritional and Socio-Economic Status. Developmental Psychobiology. DOI 10.1002/dev.21413

Goodwin JS, Goodwin JM, Garry PJ. (1983). Association between nutritional status and cognitive functioning in a healthy elderly population. JAMA.; 249:2917–2921.

Goon TD, Toriola LA, Shaw SB, Amusa OL, Monyeki AM, Akinyemi O. *et al*. (2011). Anthropometrically determined nutritional status of urban primary school children in Makurdi, Nigeria. BMC Public Health;11:769

Haile, D., Gashaw, K., Nigatu, D., Demelash, H. (2016). Cognitive function and associated factors among school age children in Goba Town, South-East Ethiopia. Cognitive Development 40 (2016) 144–151

Hassing L, Wahlin A, Winblad D, Backman L. (1999). Further evidence on the effects of vitamin B12 and folate levels on episodic memory functioning: a population-based study of healthy very old adults. Biol Psychiatry.;45:1472–1480.

Hoyland A, Dye L and Lawton C. (2009). A systematic review of the effect of breakfast on the cognitive performance of children and adolescents. Nutr Res Rev 22, 220–243.

Iannotti L, Jean Louis Dulience S, Wolff P, Cox K, Lesorogol C, Kohl P. (2016). Nutrition factors predict earlier acquisition of motor and language milestones among young children in Haiti. Acta Paediatr 105:e406–11.

Kamath S. M., Venkatappa K. G., Sparshadeep E. M. (2017) Impact of Nutritional Status on Cognition in Institutionalized Orphans: A Pilot Study. Journal of Clinical and Diagnostic Research. 2017 Mar, Vol-11(3): CC01-CC04

Kubik MY, Lytle LA, Hannan PJ, Perry CL, Story M. (2003). The association of the school food environment with dietary behaviors of young adolescents. Am J Public Health; 93(7):1168-1173.

Larson LM, and Yousafzai AK. (2017). A meta-analysis of nutrition interventions on mental development of children under-two in low- and middle-income countries. Matern Child Nutr 2017;13.

MacIntyre J, McTaggart J, Guerrant RL, Goldfarb DM. (2014). Early childhood diarrhoeal diseases and cognition: are we missing the rest of the iceberg? Paediatr Int Child Health 34:295–307.

McCoy D.C., Peet, E.D., Ezzati, M., Danae,i G., Black, M.M., Sudfeld, C.R., Fawzi, W., Fink, G. (2016). Early childhood developmental status in low- and middle-income countries: national, regional, and global prevalence estimates using predictive modeling. PLoS Med 13:e1002034.

Murtaza SF, Gan WY, Sulaiman N, Mohd Shariff Z, Ismail SIF (2019) Sociodemographic, nutritional, and environmental factors are associated with cognitive performance among Orang Asli children in Malaysia. PLoS ONE 14(7): e0219841. https://doi.org/10.1371/journal. pone.0219841

Olusanya BO, Wirz SL, Renner JK. (2010). Prevalence, pattern and risk factors for under nutrition in early infancy using the WHO Multicentre Growth Reference: a community-based study. Paediatric and Perinatal Epidemiology;24:572-583. doi: 10.1111/j.1365-3016.2010.01144.x

Perignon M, Fiorentino M, Kuong K, Burja K, Parker M, *et al*. (2014) Stunting, Poor Iron Status and Parasite Infection Are Significant Risk Factors for Lower Cognitive Performance in Cambodian School-Aged Children. PLoS One 9(11): e112605. doi:10.1371/journal.pone.0112605

Raven, J. (1983). The Progressive Matrices and Mill Hill Vocabulary Scale in western societies. In S. H. Irvine and J. W. Berry (Eds.), Human Assessment and Cultural Factors (pp. 107-114). New York: Plenum Press.

Raven, J. (2000). The Raven's progressive matrices: Change and stability over culture and time. Cognitive Psychology, 41(1), 1–48. doi: 10.1006/cogp.1999.0735

Vass A. V. (1992). Standardization of raven's standard progressive Matrices for secondary school African Pupils in the Grahamstown region. Thesis submitted in partial fulfilment of the requirements for the degree of Master of Arts of Rhodes University.

Veneman AM. (2011). 30th SCN Annual session symposium on to end child hunger and under nutrition. UNICEF. Geneva.

Wahlin A, Hill RD, Winblad B, Backman L. (1996). Effects of serum vitamin B12 and folate status on episodic memory performance in very old age: a population- based study. Psychol Aging.;11:487–496.

WHO, (2009). WHO AnthroPlus for Personal Computers Manual. Software for assessing growth of the world's children and adolescents.