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Research Article

Daily Consumption of Vegetables is Associated with Improved Cognitive Performance of School-aged Children in the Greater Accra Region of Ghana

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Abstract

Poor nutrition predicts poor health and cognition of school-aged children, yet these are understudied in Ghana. This study assessed dietary intake and cognition test performance of school-aged children. A cross-sectional study involving 1,229 children, aged 9-13 years from twenty-eight (28) randomly selected government-and privately-owned primary schools in the Greater Accra Region, Ghana was undertaken. Dietary intake was assessed using a repeated 24-hour recall and patterns of food group intake by a 6-food group food frequency questionnaire. Cognition tests were performed using the Raven's Coloured Progressive Matrices (RCPM). The majority of the children did not meet the Estimated Average Requirement (EAR) for energy (86.1%), vitamins A (95.4%), E (82.2%) and B12 (63.2%), folate (64.8%) and zinc (72.6%), and did not meet the recommended dietary allowance (RDA) for fibre (91.8%). Compared to boys (46.3%), girls (54.5%) had lower odds (AOR= 0.8 p = 0.0549, 95%CI= 0.6-1.0) of performing cognition test above the 50th percentile while the 13 years old children had lower odds (AOR= 0.4, p = 0.002, 95% CI= 0.2-0.7) of performing cognition test above the 50th percentile than the 10 years old children. School children who had weekly (AOR= 0.6, p < 0.001, 95% CI= 0.5-0.8), never/occasionally consumed vegetable (AOR= 0.3, p = 0.016, 95% CI= 0.1-0.8) compared with daily consumers had lower odds of performing cognition test above the 50th percentile. The odds of performing cognition test above the 50th percentile were lower among school children who consumed below the EARs for vitamin B12 (COR= 0.8, p = 0.018, 95 CI= 0.6-1.0) and iron (COR= 0.7, p = 0.039, 95 CI= 0.5-1.0).

Nutrients intake inadequacies were high among the children studied, but girls, older children, those who consumed vegetables less frequently, consumed below the EAR for vitamin B12 and iron were less likely to perform better in cognitive test.

INTRODUCTION

The period from birth to the first 2 years of life is a critical stage for cognitive development. Cognitive functioning during early childhood predicts future cognitive competence, as cognition assessment at 2 years correlate strongly with intelligent quotient at late childhood years (6-13 years) [1]. The development of cognitive functioning is affected by multifactorial complexes including genetic influence, social and physical environment [2]. In early childhood, factors such as socioeconomic status of parent/caregiver (e.g. family income, occupation, home resources), physical environment stimulation, maternal intelligent quotient have influences on the cognitive development of children [2,3]. Besides these factors, nutrition plays an important role to ensure optimal cognitive functioning in school [4]. For school-going children, it is very important to understand how nutrition affects their cognitive ability which is needed for academic performance [5].

Cognition defines the ability to incorporate and process information received from various sources into knowledge use [6]. Cognitive processes involve learning, attention, memory, language, reasoning, and decision-making [6]. Adequate nutritional intake together with being physically fit is necessary for school children to improve cognition, increase the ability and willingness to learn, and achieve good grades in class [4], as well as promote optimum growth and reduce obesity [7]. Despite this, school children on the average have inadequate nutrients intake [8,9], which have contributed to reduced cognition levels [10]. Some studies have reported that the consumption of less healthy food (sweets snacks) by children was associated with lower scores in the cognition test which study. On the other hand, Khan et al. [11], showed that dietary fiber from vegetables/fruits supported the cognitive test performance of school children aged 6-14 years.

Poor nutrition is noted among the predictors of children's health problems [12], but these with cognition /academic performance have been understudied in developing countries like Ghana. Moreover, limited researches have focused on the association between nutrition and cognition test performance in school children, especially in Ghana [7,13]. There is also the need to use the diet-fitness approach rather than the obesity-disease approach in preventing health problems in children [12], which is less utilized in Ghana. This study aimed to investigate the relationship between dietary intake and cognitive performance among schoolchildren in Accra Metropolis.

MATERIALS AND METHODS

Study design and participants

This was a cross-sectional study involving school children aged 9 to 13 years, residing and attending government-owned and private-owned primary schools in the Greater Accra Region. A total of 1229 participants were recruited from twenty-eight (28) randomly selected primary schools in the region, to assess their dietary intakes and cognition test performance.

Study area

Greater Accra Region is regarded among the most populated regions in Ghana, with an estimated population of 4, 943,075 in 2019 [14]. Greater Accra Region is demarcated into twenty-seven (27) Metropolitan, Municipal and District Assemblies (MMDAs). Accra, which is the capital of the region, is also the capital city of Ghana. The Greater Accra Region is home to many important educational facilities in the country, and has 2,610 primary schools; comprising of 844 government-owned and 1,766 private-owned primary schools as of 2016; made of school children from different ethnicities. Study participants in the Greater Accra Region can be used to define a population of school-aged children in Ghana [15,16]. In Ghana, it is expected that children from high socio-economic income family are more likely to attend privately-owned primary schools which offer a better-quality education compared to government-owned primary schools [17]. Thus, it is likely that there would be a difference in the income status of the parents of the selected schools. The choice to conduct the study in both government and privately-owned schools was to allow comparison where necessary. Selected schools were not partakers of the Government school feeding programme, and school meals were not offered to children.

Sampling and sample size

School-going age in Ghana is defined as a child who has attained 6 years and above and can start primary education [17]. The ages of the children were determined as reported in the school registry and confirming with the children upon recruitment.

A stratified sampling approach was used. The study was undertaken in the Accra metropolis of the Greater Accra. Administratively, the metropolis is composed of 5 sub-metros, namely: Ayawaso Central, Okaikoi South, Ablekuma, Ashiedu Keteke, and Osu Klottey. Records obtained from the Ghana Education Service indicated there were about 447 public and private basic schools in the Accra metropolis as of November 2018. The schools in the metropolis were grouped into the 5 geographical strata (sub-metros). The basic schools in each sub-metro were further grouped into public and private schools. Each school was numbered, and the numbers were written on folded pieces of paper and placed in ballot boxes according to each stratum (sub-metro). Using simple random sampling, four schools each (two public and two private) were selected from Ashiedu Keteke, Okaikoi South, and Osu Klottey, whilst eight each (four public and four private) were selected from Ablekuma and Ayawaso, as a result of their relatively larger populations. In each school, all children in Primary 5 (grade 5) within 9 to 13 years were eligible and included even if the class had more than 50 children. Where there were less than 50 in the class, primary 4 children who fell within the age categories were added, by first-come-first-service, until the 50 was reached. Since some schools had less than 50 even when the two classes were combined, some children were rejected because they were 14 years or above, and/or missing data from some children, the 28 schools gave a total of 1,229 children.

Ethics

Approval for the study was obtained from the Institutional Review Board of the Kwame Nkrumah University of Science and Technology and the Ghana Educational Service (reference: GES/ACD/PG 48/VOL.11). The approval letters were sent to each school and discussed with heads of selected schools who had to approve and agreed on convenient dates for the research team to visit for data collection. Study aims and protocols were first explained to the school children. Participation was voluntary and children who verbally assented to participate in the study were recruited. All participants were given informed written consent forms and signed by parents/guardians, and parents were followed to their homes or by telephone for household data collection, which will be reported elsewhere.

Data collection

Interviews were used in collecting data from the children. Data were collected on their dietary intake of nutrients and food groups and cognition test level. Sociodemographic data such as age, gender, socioeconomic status of parents/guardians were obtained. A two-day training workshop was conducted by research experts, to train all enumerators (MSc Human Nutrition and Dietetics students) on each of the data collection tools. This was followed by a pre-testing session in a nearby unselected community basic school.

Assessment of dietary nutrient intake

A single 24-hour dietary recall on the previous day's dietary intake was to obtain the dietary intake of the schoolchildren.

Household handy measures were used to aid children in the estimation of portion sizes of food intake. The dietary assessment was conducted on the school premises one-on-one, in an unused classroom. The 24-hour dietary recall has been used by Annan et al. [9], to assess the dietary intake of schoolchildren aged 9-13 years in the Ashanti Region of Ghana. Dietary recall has limitations in the assessment of dietary intake among school-aged children due to difficulty in determining quantities. A food photographic atlas is recommended for the estimation of portion sizes for this age group but a validated atlas does not exist for Ghana. The household handy measures used were common food measures in Ghana, and familiar to the children. Portion size estimates of food and beverages consumed were later converted into grams and entered into a standardized excel spreadsheet designed by the University of Ghana, Department of Food Science and Nutrition [18] which included mostly consumed Ghanaian foods. The Excel software provided the nutrients in the food and beverages consumed by the children. The mean nutrients intakes of macro and micronutrients were calculated by the software, and nutrients intakes were compared with Estimated Adequate Requirement (EAR) [19]. The mean energy, carbohydrate, vitamin B_6, folate, vitamins A, B_{12}, C, and E, iron, zinc were compared to the estimated average requirement (EAR), while mean protein and fibre were compared to recommended dietary allowance (RDA), all using the Food and Nutrition Board, Institute of Medicine, National Academy of Sciences cut-offs [19-21]. According to the National Academy of Sciences, Food and Nutrition Board, Institute of Medicine [19-21], the age bracket of the children revealed they have the same nutrients requirements.

Assessment of food group intake patterns

A structured food frequency questionnaire (FFQ) of the six food groups; whole-grain, animal protein, plant protein, vegetable, fruit, and dairy products was used to obtain the frequency of food group consumption. The purpose of this FFQ was to assess broad patterns of intake of the major food groups and not specific foods. On the FFQ, there were six (6) possible options for frequency of consumption, namely; more than once per day, daily, 3-4 times per week, once per week, monthly, occasionally/never. Schoolchildren were allowed to select one option from the frequency of the consumption category.

Assessment of cognition test performance

The study used the Raven's Coloured Progressive Matrices (RCPM) test to assess the cognitive level of the school children. Before the test, the RCPM test procedure was explained to the participants, and the cognition test was performed in the morning in a quiet environment, at the school premises. The RCPM test contains progressively geometrical designs and patterns of six to eight options with a missing piece. The children were to choose from and fill the missing piece. The test contains three sets of twelve problems (36-coloured questions) which measures fluid intelligence by problem-solving and abstract reasoning by analogy, and has been used extensively as a culturally fair test of intelligence [22]. The children were given the RCPM booklet containing the test and answer sheets to select the correct answer for each question. This was also explained to the children before the test. One trained researcher supervised the administration of the test in each school.

Data Analysis

The IBM Statistical Package for Social Sciences version 25 (SPSS IBM Inc Chicago, USA) was used for data analysis. Absolute and relative frequencies were determined for gender, ages of children, nutrients intake, food group frequency, and Raven's cognition test scores. Kolmogorov-Smirnov test of normality was performed to determine whether all continuous variables met parametric assumptions. Also, Chi-square (Fisher's exact test) cross-tabulation was performed to find the relationship between frequencies of nutrients intake variables and cognition test percentile status. The total cognition scores were compared by food groups, age, and gender, and this was presented as mean ± SD for the continuous variables. An independent t-test and one-way analysis of variance (ANOVA) were used for parametric comparisons, while Mann Whitney 'U' test and Kruskal-Wallis test were performed for non-parametric comparisons of all continuous variables. Study variables that were significant at Chi-square/ANOVA analysis were put into the Binary logistic regression model to determine predictors of cognition test scores above the 50th percentile. Both crude and adjusted (type of school attended) odds ratios were reported. All tests were 2-tailed, and p-values < 0.05 were termed significant. Also, four quartiles (percentiles) of the total fitness variable were combined as three quartiles (percentiles) in the regression model, to strengthen the statistical test in the model.

RESULTS

Frequency of Food Group Consumption of Participants

Figure 1 indicates the frequency of consumption of food groups among participants.

Generally, wholegrain, animal protein, and vegetables were largely consumed by the majority of the children daily whereas, fruit, plant protein, and dairy product were more weekly consumed. The proportion of children with daily or more than once a day consumption of wholegrain was 73.3%, animal protein (81.7%), vegetables (49.2%) while, 42.0%, 33.1% consumed plant protein and fruit on weekly basis respectively. Less than 30% consumed fruits daily and only a quarter consumed vegetables every day. A third of the study participants (30.2%) consumed dairy products 3-4 times per week.

The Comparison of mean raw cognition test scores by frequency of food group consumption is presented in Table 1. Children with daily (21.7 ± 0.4) or more than once a day (20.7 ± 0.5) consumption of vegetables had higher total cognition test score than those with 3-4 times weekly (19.6 ± 0.5), once per week (20.4 ± 0.6), monthly (19.7 ± 1.2), and never/occasionally (18.1 ± 1.7) consumption (p = 0.011). The mean total cognition test scores did not vary by frequency of consumption of whole-grain (p = 0.875), animal protein (p = 0.255), plant protein (p = 0.106), fruit (p = 0.649) and dairy product (p = 0.481) (Table 1).

Yet, about a third of children consumed fruits and vegetables, animal and plant-based proteins, and dairy products only monthly or occasionally, and less than half of the children consumed all the six food groups daily.

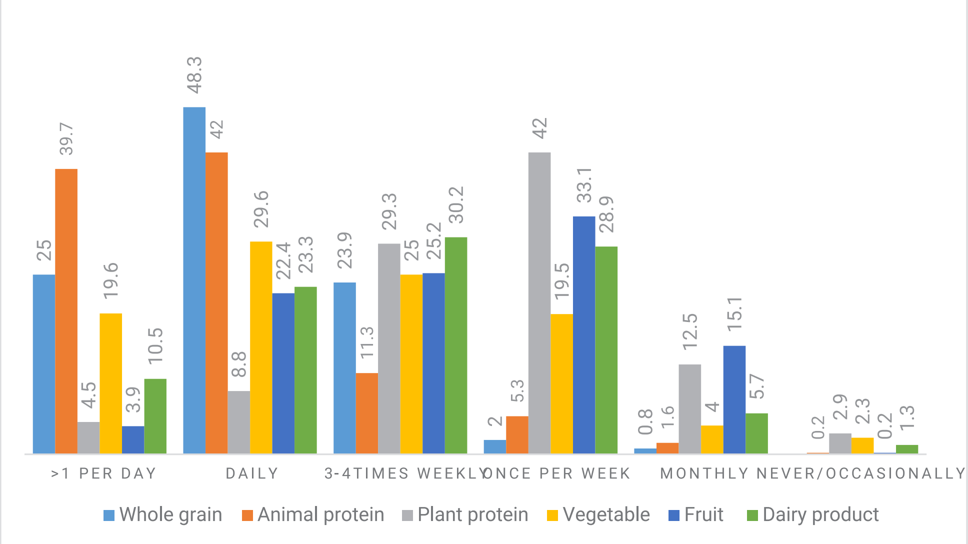

Figure 1 Frequency of consumption of food groups among participants.

Table 1: Comparisons of mean cognition test scores by frequency of food group consumption.

	Mean raw cognition test scores						
Food group	**> 1 per day**	**Daily**	**3-4times weekly**	**once per week**	**Monthly**	**Never/occasionally**	**P value**
Whole-grain	20.6±0.4	20.6±0.4	20.4±0.5	22.0±1.6	21.6±2.0	-	0.875
Animal protein	20.2±0.4	21.0±0.4	20.0±0.7	21.1±1.1	22.9±1.9	14.7±4.2	0.255
Plant protein	18.4±0.9	21.6±0.8	20.3±0.4	20.5±0.4	21.2±0.7	22.3±1.4	0.106
Vegetable	20.7±0.5	21.7±0.4	19.6±0.5[a]	20.4±0.6[a]	19.7±1.2	18.1±1.7	**0.011**
Fruit	21.3±1.1	21.1±0.5	20.6±0.5	20.2±0.4	20.5±0.6	16.5±1.5	0.649
Dairy product	20.4±0.6	21.2±0.5	20.9±0.4	19.9±0.5	19.8±1.0	20.8±2.6	0.481

Data are presented as mean±SEM (standard error mean) for total cognition test score, Alphabets with the same superscript were significant at posthoc (P=0.011). Kruskal-Wallis test, bold value is significant at p<0.05.

Nutrient Intakes of participants and its Relationship with Gender and Age Group

Nutrients adequacies and inadequacies among school children and their relationship with gender-based age group are displayed in Table 2. The majority of the school children did not meet the EAR for the following nutrients; energy (74.6%), and folate (55.8%), vitamins A (92.6%), B_{12} (54.3%) and E (73.0%), and zinc (64.0%), and did not meet RDA for fibre (91.8%). The proportions of boys and girls varied significantly by vitamins A (p = 0.054) and C (p = 0.011). The 13 years old boys (77.5%) had the highest vitamin A intake below the EAR (p = 0.054) when compared to the other gender-based age groups. For vitamin C (p = 0.011), more 13 years old boys (83.6%) had above the EAR than the other gender-based age groups. The other nutrient intakes did not significantly differ by the gender-based age group of the children (p>0.05).

The mean folate (p = 0.009) was highest among 11 years old boys (317.9±15.8µg) when compared to the other gender-based age groups. The mean vitamin C intake (p = 0.003) was highest among 9 years old boys (88.1±18.6mg) when compared to the other gender-based age groups. The mean vitamin E intake (p = 0.013) was highest among 9 years old girls (8.4±0.9mg) when compared to the other gender-based age groups. The other nutrient intake did not significantly differ by the gender-based age group of the children (p>0.05)

Relationship between Cognition test Performance and Nutrient Intakes

Table 3 presents the relationship between nutrient intakes and cognition test performance. Proportions of children who had cognition test scores above the 50th percentile and below the 50th percentile were significantly related to vitamin B_{12} (p = 0.021) and iron (p = 0.044) intakes. More children who scored below the 50th percentile in cognition test (57.7%) consumed below the EAR for vitamin B_{12} than those who scored above the 50th percentile (50.7%). Likewise, more children who scored below the 50th percentile in cognition test (22.1%) consumed below the EAR for iron than those who scored above the 50th percentile (17.3%). However, the other nutrient intakes did not significantly vary by children with above the 50th percentile and below the 50th in cognition test performance (p>0.05). An unreported result of bivariate correlation showed no association between nutrient intakes and raw cognition test scores (p>0.05).

Table 2: Nutrient intake, and gender-based on age group.

		Gender-based on Age group										
Nutrients intake	**n (%)**	**9yrs boys**	**9yrs girls**	**10yrs boys**	**10yrs girls**	**11yrs boys**	**11yrs girls**	**12yrs boys**	**12yrs girls**	**13yrs boys**	**13yrs girls**	**P value**
n(%), n= 1229		40(3.3)	40(3.3)	136(11.1)	153(12.4)	204(16.6)	219(17.8)	148(12.0)	149(12.1)	63(5.1)	77(6.3)	
Energy												
Mean	1578.0 ± 17.8	1519.1 ± 77.5	1537.3 ± 91.8	1616.2 ± 57.1	1558.3 ± 49.8	1583.9 ± 44.7	1615.5 ± 46.7	160.6.9 ± 50.9	1465.7 ± 39.1	1648.8 ± 76.5	1580.4 ± 77.7	0.855ǂ
Below EAR	883 (74.6)	32 (82.1)	26 (65.0)	88 (69.3)	104 (72.7)	154 (77.0)	147 (69.3)	115 (79.3)	116 (81.7)	50 (82.0)	51 (68.0)	0.037¥
Within EAR	301(25.4)	7(17.9)	4(35.0)	39(30.7)	39(27.3)	46(23.0)	65(30.7)	30(20.7)	26(18.3)	11(18.0)	24(32.0)	
Protein												
Mean	47.6 ± 0.6	45.3 ± 2.8	47.9 ± 3.5	48.8 ± 2.0	47.3 ± 1.8	49.5 ± 1.6	48.9 ± 1.5	46.8 ± 1.8	44.4 ± 1.4	47.1 ± 2.8	46.9 ± 2.5	0.840ǂ
Below RDA	356(30.1)	10(25.0)	12(30.0)	37(27.2)	42(27.5)	55(27.1)	65(29.8)	52(35.1)	41(27.7)	18(28.6)	26(33.8)	0.852¥
Within RDA	828(69.9)	30(75.0)	28(70.0)	99(72.8)	111(72.5)	148(72.9)	153(70.2)	96(64.9)	107(72.3)	45(71.4)	51(66.2)	
Carbohy-drate												
Mean	227.2 ± 3.1	219.8 ± 17.2	207.9 ± 13.7	235.3 ± 10.0	221.9 ± 8.7	231.1 ± 7.4	243.4 ± 7.8	225.7 ± 9.1	202.8 ± 6.7	230.8 ± 13.8	227.5 ± 13.1	0.217ǂ
Below EAR	69(5.8)	3(7.7)	3(7.5)	9(7.1)	9(6.3)	11(5.5)	12(5.7)	5(3.4)	7(4.9)	3(4.9)	7(9.3)	0.883¥
Within EAR	1115(94.2)	36(92.3)	37(92.5)	118(92.9)	134(93.7)	189(94.5)	200(94.3)	140(96.6)	135(95.1)	58(95.1)	68(90.7)	
Fibre												
Mean	16.6 ± 0.3	14.8 ± 1.4	15.6 ± 1.2	16.7 ± 0.8	15.4 ± 0.7	17.3 ± 0.7	18.1 ± 0.6	16.6 ± 0.9	15.6 ± 0.7	15.6 ± 1.1	17.1 ± 1.1	0.065ǂ
Below RDA	1087 (91.8)	37 (92.5)	39(97.5)	119(87.5)	136(88.9)	179(88.2)	192(88.1)	127(85.8)	138(93.2)	57(90.5)	70(90.9)	0.448ǂ
Within RDA	97(8.2)	3(7.5)	1(2.5)	17(12.5)	17(11.1)	24(11.8)	26(11.9)	21(14.2)	10(6.8)	6(9.5)	7(9.1)	
Vitamin B_6												
Mean	1.3 ± 0.0	1.2 ± 0.1	1.2 ± 0.1	1.3 ± 0.1	1.2 ± 0.0	1.3 ± 0.1	1.5 ± 0.1	1.4 ± 0.1	1.3 ± 0.0	1.2 ± 0.1	1.4 ± 0.1	0.622ǂ
Below EAR	237(20.0)	8(20.5)	11(27.5)	33(26.0)	31(21.7)	46(23.0)	35(16.5)	27(18.6)	19(13.4)	10(16.4)	17(22.7)	0.206¥
Within EAR	947(80.0)	31(79.5)	29(72.5)	94(74.0)	112(78.3)	154(77.0)	177(83.5)	118(81.4)	123(86.6)	51(83.6)	58(77.3)	
Folate												
Mean	288.1 ± 6.2	236.9 ± 26.6	250.7 ± 31.0	268.3 ± 17.5	237.5 ± 15.3	317.9 ± 15.8	315.4 ± 15.9	284.6 ± 18.4	284.2 ± 17.5	299.0 ± 29.5	313.1 ± 25.7	**0.009ǂ**
Below EAR	661(55.8)	26(66.7)	26(65.0)	73(57.5)	93(65.0)	103(51.5)	103(48.6)	83(57.2)	83(58.5)	34(55.7)	37(49.3)	0.065¥
Within EAR	523(44.2)	13(33.3)	14(35.0)	54(42.5)	50(35.0)	97(48.5)	109(51.4)	62(42.8)	59(41.5)	27(44.3)	38(50.7)	
Vitamin B_{12}												
Mean	2.2 ± 0.1	2.1 ± 0.3	2.3 ± 0.4	2.4 ± 0.3	2.5 ± 0.2	2.3 ± 0.2	2.3 ± 0.2	2.1 ± 0.2	1.8 ± 0.2	1.7 ± 0.2	1.6 ± 0.2	0.067ǂ
Below EAR	643(54.3)	16(41.0)	23(57.5)	58(45.7)	69(48.3)	111(55.5)	120(56.6)	81(55.9)	80(56.3)	36(59.0)	49(65.3)	0.121¥
Within EAR	541(45.7)	23(59.0)	17(42.5)	69(54.3)	74(51.7)	89(44.5)	92(43.4)	64(44.1)	62(43.7)	25(41.0)	26(34.7)	
Vitamin A												
Mean	186.1 ± 5.7	190.7 ± 31.1	193.5 ± 30.6	197.9 ± 19.3	178.8 ± 15.4	197.2 ± 15.1	206.4 ± 15.6	198.5 ± 16.2	162.9 ± 14.3	143.9 ± 10.1	141.7 ± 14.3	0.206ǂ

Below EAR	1096(92.6)	37(94.9)	37(92.5)	119(93.7)	134(93.7)	179(89.5)	188(88.7)	133(91.7)	136(95.8)	61(100.0)	72(96.0)	**0.054ƚ**
Within EAR	88(7.4)	2(5.1)	3(7.5)	8(6.3)	9(6.3)	21(10.5)	24(11.3)	12(8.3)	6(4.2)	0(0.0)	3(4.0)	
Vitamin C												
Mean	72.9 ± 1.7	88.1 ± 18.6	69.7 ± 7.3	66.8 ± 4.6	65.5 ± 3.7	64.6 ± 3.3	74.5 ± 4.8	83.7 ± 4.6	72.8 ± 3.4	78.3 ± 5.9	83.3 ± 7.5	**0.003ǂ**
Below EAR	349(29.5)	15(38.5)	12(30.8)	40(31.5)	52(36.4)	72(36.0)	62(29.2)	31(21.4)	33(23.2)	10(16.4)	22(29.3)	**0.011¥**
Within EAR	834(70.5)	24(61.5)	27(69.2)	87(68.5)	91(63.6)	128(64.0)	150(70.8)	114(78.6)	109(76.8)	51(83.6)	53(70.7)	
Vitamin E												
Mean	6.9 ± 0.1	7.1 ± 0.7	8.4 ± 0.9	6.8 ± 0.4	6.8 ± 0.4	6.5 ± 0.3	6.4 ± 0.3	7.8 ± 0.4	7.1 ± 0.4	7.8 ± 0.5	6.7 ± 0.5	**0.013ǂ**
Below EAR	864(73.0)	29(74.4)	26(65.0)	95(74.8)	109(76.2)	150(75.0)	163(76.9)	95(65.5)	100(70.4)	41(67.2)	56(74.7)	0.345¥
Within EAR	320(27.0)	10(25.6)	14(35.0)	32(25.2)	34(23.8)	50(25.0)	49(23.1)	50(34.5)	42(29.6)	20(32.8)	19(25.3)	
Iron												
Mean	10.5 ± 0.5	9.5 ± 0.7	9.5 ± 0.8	10.9 ± 0.6	10.0 ± 0.5	11.1 ± 0.4	11.2 ± 0.4	10.5 ± 0.5	9.3 ± 0.4	10.0 ± 0.7	10.6 ± 0.7	0.187ǂ
Below EAR	238(20.1)	8(20.5)	11(27.5)	26(20.5)	38(26.6)	27(13.5)	34(16.0)	35(24.1)	33(23.2)	11(18.0)	15(20.0)	0.085¥
Within EAR	946(79.9)	31(79.5)	29(72.5)	101(79.5)	105(73.4)	173(86.5)	178(84.0)	110(75.9)	109(76.8)	50(82.0)	60(80.0)	
Zinc												
Mean	6.7 ± 0.1	6.0 ± 0.5	6.5 ± 0.6	6.7 ± 0.3	6.5 ± 0.3	7.2 ± 0.3	7.1 ± 0.3	6.6 ± 0.3	6.1 ± 0.2	6.5 ± 0.4	6.4 ± 0.4	0.216ǂ
Below EAR	758(64.0)	33(84.6)	26(65.0)	82(64.6)	87(60.8)	124(62.0)	123(58.0)	96(66.2)	99(69.7)	39(63.9)	49(65.3)	0.127¥
Within EAR	426(36.0)	6(15.4)	14(35.0)	45(35.4)	56(39.2)	76(38.0)	89(42.0)	49(33.8)	43(30.3)	22(36.1)	26(34.7)	

Data are presented as frequency (percentage), mean ± SEM (standard error mean), yrs- Years ǂ- Kruskal-Wallis, ¥- Chi-square P value, ƚ- Fisher's exact P value, bold values are significant at p<0.05

Predictors of Poor Cognition test Performance

A binary regression (crude and adjusted) analysis showing predictors of cognition test performance above the 50th percentiles is presented in Table 4. Girls had lower odds (AOR= 0.8 p = 0.0549, 95%CI= 0.6-1.0) of performing above the 50th percentile in cognition test than boys. School children aged 13 years had lower odds (AOR= 0.4, p = 0.002, 95%CI= 0.2-0.7) of performing cognition test above the 50th percentile than the 10 years old children. School children who had weekly (AOR= 0.6, p < 0.001, 95%CI= 0.5-0.8), monthly (AOR= 0.6, p = 0.073, 95%CI= 0.3-1.1), did never/occasionally (AOR= 0.3, p = 0.016, 95%CI= 0.1-0.8) consume vegetable had lower odds of performing cognition test above the 50th percentile than those with daily vegetable intake. The odds of performing cognition test above the 50th percentile were lower among school children who consumed below the EARs for vitamin B_{12} (COR= 0.8, p = 0.018, 95CI= 0.6-1.0) and iron (COR= 0.7, p = 0.039, 95CI= 0.5-1.0).

DISCUSSION

Cognition is required for academic performance in schoolchildren [5], and evidence suggests good nutrition can improve cognitive ability [4]. The study was based on the hypothesis that nutrient intakes within the EAR of schoolchildren aged 9-13 years are associated with cognitive ability, which we measured by the Raven Coloured Progressive Matrix.

This study suggests that both the quantity and quality of dietary intake of the school children in Accra are inadequate. In this study majority of the children did not meet the EAR for even energy (74.6%), folate (55.8%), vitamins A (92.6%), B_{12} (54.3%) and E (73.0%), and zinc (64.0%), and did not meet RDA for fibre (91.8%), from the 24-hour dietary recall data. The huge proportions not meeting the dietary nutrient intakes are worrying. A previous study [9] reported that school children, aged 9-13 years in Kumasi Metropolis, Ghana were not meeting their daily EARs for some micronutrients; which turn to explain that school children in Ghana generally might have inadequate nutrient intakes. If this trend exists, then it calls for the necessary actions to address the nutritional needs of these children. We also found that the proportion of inadequate folate and vitamin A were highest among 9 years old girls and 13 years old boys, while the 13 years old boys had the highest adequate intake of vitamin C. Moreover, the 11 years old boys were more likely to have a higher mean folate intake, while 9 years old girls were more likely to have a higher mean vitamin E intake. The reasons for the gender-based age differences in nutrient intakes need further exploration. Children eat what is accessible and available to them [23], and so children must be provided with the right quantity and quality of foods needed to meet their daily nutrient requirements as well as support their growing body tissues. We found that children who consumed below the EAR for Iron and vitamin B_{12} intakes were less likely to score above the 50th percentile in Raven's cognition test. This implies that adequate iron and vitamin B_{12} might support cognition test performance and thus requires further exploration of these micronutrients. Although other nutrients were not associated with cognition test performances, children who were above the 50th percentile score in cognition test had overall better nutrient intakes (both macronutrients and micronutrients) than those with below the 50th percentile score.

The quality of food intake measured by the patterns of consumption of the six food groups also reflects findings that give a cause for concern. The food frequency data showed wholegrain, animal protein, and vegetables were more regularly consumed by the children than fruits, plant protein, and dairy products. More specifically, less than 30% consumed fruits daily and only a quarter consumed vegetables daily. These signify that protein and micronutrients are likely to be inadequate, confirming the findings from the 24-hour dietary recall which reported large proportions of inadequate nutrients intake. Although the frequency of food group consumption was not associated with cognitive test scores except for vegetable intake, the levels of low frequency of consumption are unacceptable which needs further evaluation.

Generally, one in two (50.5%) children scored below the 50th percentile for Raven's cognition test, which was poorer than the previous study in a different location of school children in Ghana [9] where 36.2% of the school children scored below the 50% percentile. From the two studies, cognition levels of Ghanaian school children will likely vary from location to location. The findings also imply that Ghanaian schoolchildren are likely to perform poorer in cognition tests but this would be more conclusive and comparable if there was national data on cognitive scores of schoolchildren in Ghana. Thus, the study calls for attention into the matter of obtaining national data for cognition scores among schoolchildren in Ghana, which can be used to make informed decisions based on the geographical location of children. In the regression analysis, older children, those who consumed vegetables less frequently, girls, and those with lower fitness levels had poorer cognitive test performance. This explains the complex factors that are associated with the cognitive ability of children. But for this study, consuming vegetables less frequently was the environmental stimuli that might affect the cognitive performance of the schoolchildren. The mechanisms in which dietary intakes can influence cognitive ability in children remain unclear, but it likely that essential micronutrients missing in low vegetable diet are the culprits. While long term consumption of vegetables by the children might have contributed to higher scores in the Raven's cognition test, the impact of nutrients from the diet may be more effective when studied longitudinally [24-29]. School children must frequently consume a healthier diet, to support cognitive functioning and school learning activities.

CONCLUSIONS

The frequency of consumption from the food groups was adequate among the school children but their current nutrient intakes were inadequate. The 13 years old children, being a girl, those who either weekly or never consumed vegetables, those who consumed below the EAR for vitamin B_{12} and iron, and having a fitness score below the 40th percentile were associated with lower risk of performing well (above the 50th percentile) in the Raven's test cognition test. A more balanced intervention approach to promote good nutritional practices and physical activity in children is necessary for the basic school environment to increase physical fitness levels, improve daily nutritional needs for better academic performance.

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