International Journal of Nutrition Sciences

Journal Home Page: ijns.sums.ac.ir

ORIGINAL ARTICLE

Effect of Habitual Breakfast Consumption on School Performance and Cognitive Ability of School Children Aged 6-15 Years in Khartoum State, Sudan

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ARTICLE INFO

Keywords:
Breakfast
School children
Performance
Cognitive ability
Sudan

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Received: May 18, 2025
Revised: August 14, 2025
Accepted: August 20, 2025

ABSTRACT

Background: Breakfast has been described as the most important meal of the day, contributing substantially to daily nutrient intake and energy needs. Breakfast consumption has an association with learning and better school performance in children. This study identified the effect of habitual breakfast consumption on school performance and cognitive ability among school children aged 6-15years old in governmental basic schools in Khartoum State, Sudan.

Methods: In a cross-sectional study by cluster multi-stage random sampling, a total of 770 students were enrolled. A designed interview questionnaire, laboratory investigation (hemoglobin and vitamin A levels) together with determination of body mass index (BMI) were undertaken to assess the school performance and cognitive ability in these children.

Results: Sixty-four percent of participants came from poor regions and 29% reported skipping breakfast. Nocturnal visual problems were found among 36% of school children. The BMI of the students indicated that 26.4% were severely underweight and 38.7% were thin. The most common breakfast choices were bread with tameia and milk tea with biscuits (52%). Most school-aged children in primary schools across Khartoum State lacked consistent breakfast habits, often skipping breakfast during the weekdays. The financial situation of their families significantly influenced their breakfast patterns. Regarding academic achievement, 28.7% of the students achieved the pass level and 25.5% showed a weak performance.

Conclusion: It is worth noting that the intervention program can lead to the disappearance of the signs for vitamin A deficiency and a notable improvement in hemoglobin level, nutritional status, school performance, and student attendance.

Please cite this article as: Ali BAA, Idris SM, Al Foraih M, Dawi EAR, Nour AAM, Ibrahim MAEM. Effect of Habitual Breakfast Consumption on School Performance and Cognitive Ability of School Children Aged 6-15 Years in Khartoum State, Sudan. Int J Nutr Sci. 2025;10(3): doi:

Introduction

Skipping breakfast is considered a health problem for children and adolescents. During 1999-2006, National Health and Nutrition Survey of the United States reported that between 20% and 30% of children and adolescents skipped breakfast frequently (1). In India, the proportion of children skipping breakfast regularly was even higher (more than 50%) (2). There is growing evidence that skipping breakfast has a negative impact on cognition, motivation, academic achievement, and test scores for this age group (3, 4). Nonetheless, these studies did not involve any interventional approach; instead, they observed participants' tasks after breakfast consumption. It is generally recognized that both eating late and skipping breakfast are commonly considered risk factors for unhealthy metabolic profiles (5, 6).

Some studies have confirmed that breakfast consumption can have a positive impact on cognition through various mechanisms as memory is an important component of academic performance, and these studies indicated improvements among individuals who had breakfast (5, 6). A correlation was found between the intake of carbohydrates, iron, and vitamin B3 during breakfast and memory scores (7). It has been demonstrated that the dietary intake of energy, protein, and iron has a positive impact on participants' performance and also a substantial increase in energy and protein consumption by at least 20% (8). Additionally, an improved attendance and school breakfast participation can lead to a reduction in hunger, as well as an improvement in mathematics grades and behavior when compared to children who did not decrease their nutritional risk (9).

It was shown that neither wasting nor being underweight had an impact on cognitive ability, but stunting was significantly linked to a lower cognitive ability (10, 11). The research concluded that iron deficiency anemia (IDA) and iron deficiency (ID) were associated with decreased cognitive ability among first-grade children (10).The importance of breakfast for academic achievement is reflected in the effects of breakfast on cognitive performance (12, 13). Children who consistently eat breakfast tend to have better nutritional profile in comparison to those who skipped breakfasts (14). Factors such as overweight, inadequate energy and fat intake, academic grades, memory, focus, and attendance were included in the comparison between students who skipped breakfast and those who had breakfast (15). Therefore, breakfast plays a crucial role in providing sufficient nutrition to school children and can significantly impact on cognitive abilities. Consuming breakfast lead to improvement in cognitive performance at school during the morning when compared to skipping breakfast, especially in tasks such as Hard Word Recall, Serial 3's, and Serial 7's (16).

Thus, the habits around breakfast consumption present a significant health concern during childhood and adolescence, particularly about skipping breakfast. Additionally, there is a critical lack of awareness about the importance of breakfast among the Sudanese population. No previous studies in Sudan have explored the impact of regular breakfast consumption on nutritional status, academic performance, and levels of hemoglobin and vitamin A. It is of utmost importance to address the issue of skipping breakfast and to bring attention of authorities such as the Ministry of Health, Ministry of Education, teachers, and parents. So this study was undertaken to identify the effect of habitual breakfast consumption on school performance and cognitive ability among school children aged 6-15years old in governmental basic schools in Khartoum State, Sudan.

Materials and Methods

The current study was carried out in collaboration with the School Health Team and the Ministry of Health, focusing on specific schools. The Ministry of Health informed the schools about planned visits and after obtaining parental consent, medical visits were conducted. The study involved male and female students who attended selected government basic schools and aged between 6 and 15 years old. The study utilized a cross-sectional descriptive design and employed a multistage cluster random sampling technique (MCRS) by focusing on primary schools in three different areas, which were spread across seven administrative units by utilizing data obtained from the Ministry of Education. The study involved a sample size of up to 770 primary school students determined by use of the statistical formula of Thompson:

$$n = \frac{N \times p(1-p)}{[(N-1)(d^2 \div z)] + p(1-P)} \quad (17).$$

In the formula for the estimation of a single population proportion in a prevalence study (17), '*n*' represented the required sample size, '*N*' stands for the population size, '*p*' signified the interested proportion (often assumed to be 50% prevalence), '*Z*' was corresponded to the standard score for a 95% confidence level (CI: 1.96), and '*E*' represented the margin of error (typically estimated at 5%). So the sample size for this study was:

$$n = \frac{20.870 \times 0.5 \times (1-0.5)}{[(20.870 - 1 \times (0.05^2 - 1.95)^2] + 0.5 \times (1-0.5)} = 770.$$

When the students from each school were selected by utilizing a highly effective systemic random sampling method, the systemic sampling interval (i) was calculated using the formula (i)=N/n. Next, a starting number (r) was randomly selected from the student list. Students were then added to the sample at intervals of the starting number (r, r+I, r+2i). The sample was selected based on specific criteria including (i) Children aged between 6 to 15 years old; (ii) Only students from the chosen school who were aligned with the school health program (MOH); (iii) Children who expressed a keen interest in participation in the study and (iv) Children who were free of any physical complications.

Exclusion criteria were determined as (i) Children who were not within the specified age range; (ii) Children who did not attend the school health program; (iii) Children who showed no interest in participation in the study and (iv) Children with acute infections (e.g., Malaria, respiratory infections, diarrhea, Giardiasis) within 15 days before the study to ensure accurate and unbiased results. This study commenced with the arrival of the School Health Team from the State Ministry of Health (SMoH) for their annual visit. Upon receiving the SMoH notification and our study's written consent, the school headmaster expedited the scheduling of the SMoH visits as soon as he received the completed approval forms, including consent for physical examination and blood samples.

A team of medical professionals, including doctors, optometrists, nutritionists, lab technicians, and psychologists held open clinic days at the school. The teacher informed parents about abnormal findings, managed referrals, and ensured follow-up with local health facilities. The students underwent medical exams and were given Retinol Palmitate capsules, which firstly contained 200.000 IU (2 capsules), 1 capsule after 2 days, and 1 capsule after 1 week according to the State Ministry of Health guidelines. The students also received both therapeutic and prophylactic doses. They were interviewed, had eye exams, and had blood samples to measure the hemoglobin level. The investigations were conducted using the Mission plus Blood Hemoglobin Monitoring System for hemoglobin level for students' blood samples obtained through finger pricks. The procedures were carried out cleanly, and a consent form was obtained for all medical activities. Capillary blood was collected, applied to the test device, and tested immediately; while proper waste disposal procedures were followed for used materials.

Children's weight and height were measured using a standard WHO balance, and the z-scores of body mass index (BMI)-for-age were calculated based on WHO standards. Breakfast frequency and energy intake were evaluated through a 24-hour recall over the past 7 days to document meals, portion sizes and nutrient estimates from the food composition tables (18, 19). Cognitive ability was assessed using the Henman-Nelson Tests of Mental Ability for children aged 6-10 and 11-15 years old (20). Academic performance was determined according to the standard grading system adopted by Sudan Ministry of Education.

SPSS software (Version 20, Chicago, IL, USA) was employed for statistical analysis. First, data's normality was assessed using the Kolmogorov-Smirnov test. The descriptive analysis included examining frequencies and measuring the central tendency (such as mean, mode, median, and standard deviation) for continuous variables to evaluate normality. Categorical variables were summarized using frequencies and percentages. For inferential analysis, paired-samples t-test and Wilcoxon test were utilized to compare pre-and post-intervention means for parametric and non-parametric dependent variables, respectively. Correlation tests were used to examine exposure-outcome relationships, utilizing Pearson's "R" coefficient for parametric and Spearman correlation for non-parametric variables. Finally, multinomial regression analysis (MLR) was applied to identify the most influential variable on academic performance and cognitive ability within the study group. A p value less than 0.05 was considered statistically significant.

Results

Demographic characteristics of participants were shown in Table 1 revealing that the distribution of students by age was skewed to the left, with a mean of 11.6 years (SD=1.98). The median age was 12 years, ranging from six to fifteen years old. The sample consisted of 770 participants, while 49% (n=377) of the students were boys and 51% (n=393) were girls. Participants' habitual breakfast consumption highlighted that 71% of primary school students prioritized having breakfast, whereas 29% consistently skipped the breakfast meal. Girls were significantly more likely to eat breakfast than boys [74.3% vs. 67.6%), $\chi^2(1, n=770)=4.53$, ($p=0.033$)]. It also illustrated the economic situation of the students' families. According to the school records, 64% of students' families had a low income which indicated a poor socioeconomic status for most of the families. Thus, students from families with higher economic status were more likely to eat breakfast [$\chi^2(2, n=770)=12.21$ ($p=0.002$)]. Figure 1 reveals that out of the total, 18 parents were deceased, and many parents completed primary education, with 56% being mothers and 38% being fathers.

Table 1: Characteristics of enrolled students (n=770).

Variable	Number	%
Age in years		
Median	12	
Min-Max	6	15
Sex of participants		
Boys	377	49
Girls	393	51
Habitual breakfast consumption		
Having breakfast	547	71
Not having breakfast	223	29
Economic situation of the students' families		
Poor	492	64%
Good	242	31
Very good	36	5

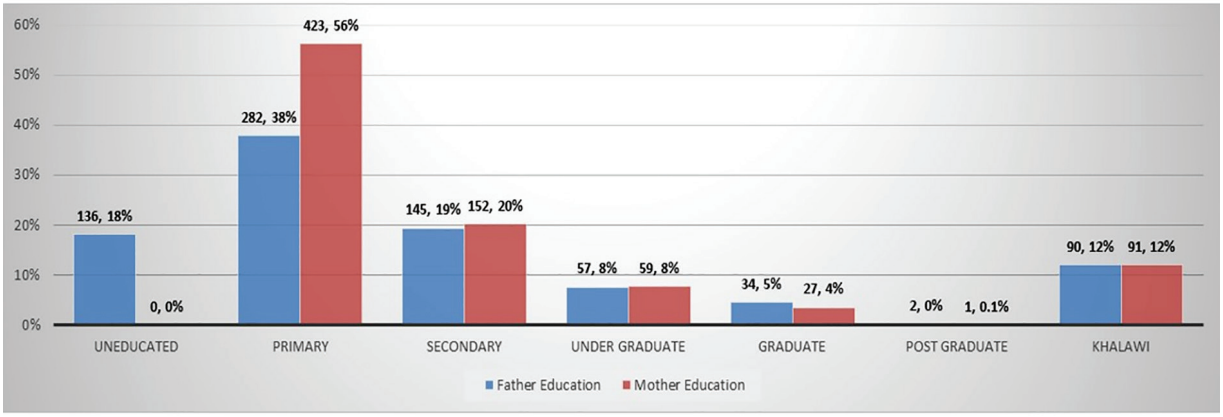

Figure 1: Parents' level of education. A significant association was between mother's education and habitual breakfast consumption (p=0.008). A significant association was between mother's educational level and student academic performance (p=0.014).

A chi-square test showed a significant association between mother's education level and habitual breakfast consumption [$\chi^2(2, n=770)=9.65$ (p=0.008)]. A significant association between mother's educational level and student academic performance was noted [$\chi^2(4, n=770)=12.47$ (p=0.014)].

In Table 2, the data illustrates that the average hemoglobin level was 11g/dL (SD=1.86) and the minimum recorded hemoglobin level was 6 g/dL, while the maximum was 15 g/dL. Students who regularly consumed breakfast had significantly a higher mean hemoglobin level (11.2 g/dL, SD=1.8) than those who skipped breakfast [(10.5 g/dL, SD=2.0), t (768)=4.32, (p<0.001)]. The BMI z-score for age revealed that 26.4% of students were severely thin, 38.7% were thin, and 31.5% were within the normal weight range for their age. Additionally, the eye examination results demonstrated that 94.9% of students displayed no vision impairments, and 64.4% showed no signs of night blindness. Visual problems, however, were more prevalent among those who skipped breakfast (8.1%) when compared to those who ate breakfast (4.0%) [$\chi^2(1, n=770)=5.12$, (p=0.024)]. Similarly, night blindness was more common among students who did not consume breakfast [$\chi^2(1, n=740)=6.38$, (p=0.012)]. Moreover, the data indicated that a significant percentage of students exhibited inadequate levels of energy, protein, carbohydrates, and fats (52.6%, 63.3%, 51.2%, and 53.6%, respectively). Students who skipped breakfast were significantly more likely to have inadequate protein intake (79% vs. 57%) [$\chi^2(1, n=770)=32.1$, (p<0.001)], and inadequate energy intake (69% vs. 47%) [$\chi^2(1, n=770)=25.3$, (p<0.001)]. Figure 2 shows that 45% of the students consumed daily breakfast frequently; while 43.7% skipped breakfast with a ratio of 1:1. However, the difference was not statistically significant [$\chi^2(1, n=770)=0.14$, (p=0.71)].

In Figure 3, it was shown that 76% of the students did not bring food to school because they could not afford to buy food any stuff, while a significantly higher proportion were compared to other reasons (p<0.001). Additionally, 11% of the students' disliked eating breakfast, while 4% did not want to eat during recess (p=0.02). Furthermore, 2.3% and 0.4% of the students were influenced by their family and friends' eating habits (p=0.05).

Table 2: Clinical parameters of hemoglobin value, the Body Mass Index (BMI), visual problems, night vision, energy level and nutritional status of the students (n=770).

Variable	Category	Number (%)	Group Comparison	*P* value	MLR Association
Hemoglobin (g/dL)	Mean±SD	11±1.86	t(768)=4.32	<0.001	Significant predictor of academic performance (p=0.017)
	Min-Max	6-15			
BMI-for-age Z score	Severe thinness	203 (26.4%)	χ^2(2, n=770)=8.21	0.016	Underweight linked to poor performance (p=0.022)
	Thinness	298 (38.7%)			
	Normal	243 (31.5%)			
	Overweight	19 (2.5%)			
	Obese	7 (0.9%)			
Visual problems	Yes	39 (5.1%)	χ^2(1, n=770)=5.12	0.024	Not significant in MLR
	No	731 (94.9%)			
Night blindness	Yes	274 (35.6%)	χ^2(1, n=740)=6.38	0.012	Linked to lower cognitive ability (p=0.031)
	No	496 (64.4%)			
Energy intake	Inadequate	405 (52.6%)	χ^2(1, n=770)=25.3	<0.001	OR=1.8 for failing school (p=0.021)
	Adequate	226 (29.4%)			
	Excessive	139 (18.0%)			
Protein intake	Inadequate	487 (63.2%)	χ^2(1, n=770)=32.1	<0.001	r=0.42 with academic performance (p<0.001)
	Adequate	276 (35.8%)			
	Excessive	7 (1.0%)			
Carbohydrate intake	Inadequate	394 (51.2%)	Not significant	>0.05	Not significant in MLR
	Adequate	328 (42.6%)			
	Excessive	48 (6.2%)			
Fat intake	Inadequate	413 (53.6%)	Not significant	>0.05	r=–0.35 with cognitive ability (p<0.001)
	Adequate	326 (42.4%)			
	Excessive	31 (4.0%)			

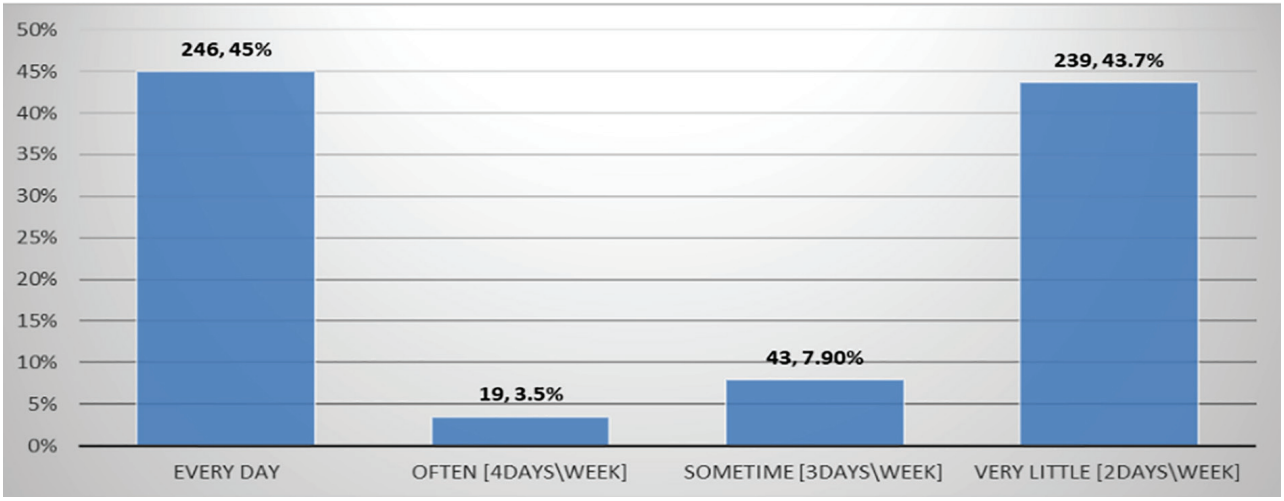

Figure 2: The frequency of breakfast intake among students. The difference was not statistically (p=0.71).

Table 3 identified the most frequently consumed breakfast items among students. The combination of bread with tameia and milk tea accompanied by biscuits emerged as the most popular choice, enjoyed by 52% of participants [χ^2(1, n=547)=342.5, (p<0.001)]. Such results highlight the strong preference for this breakfast combination among the students.

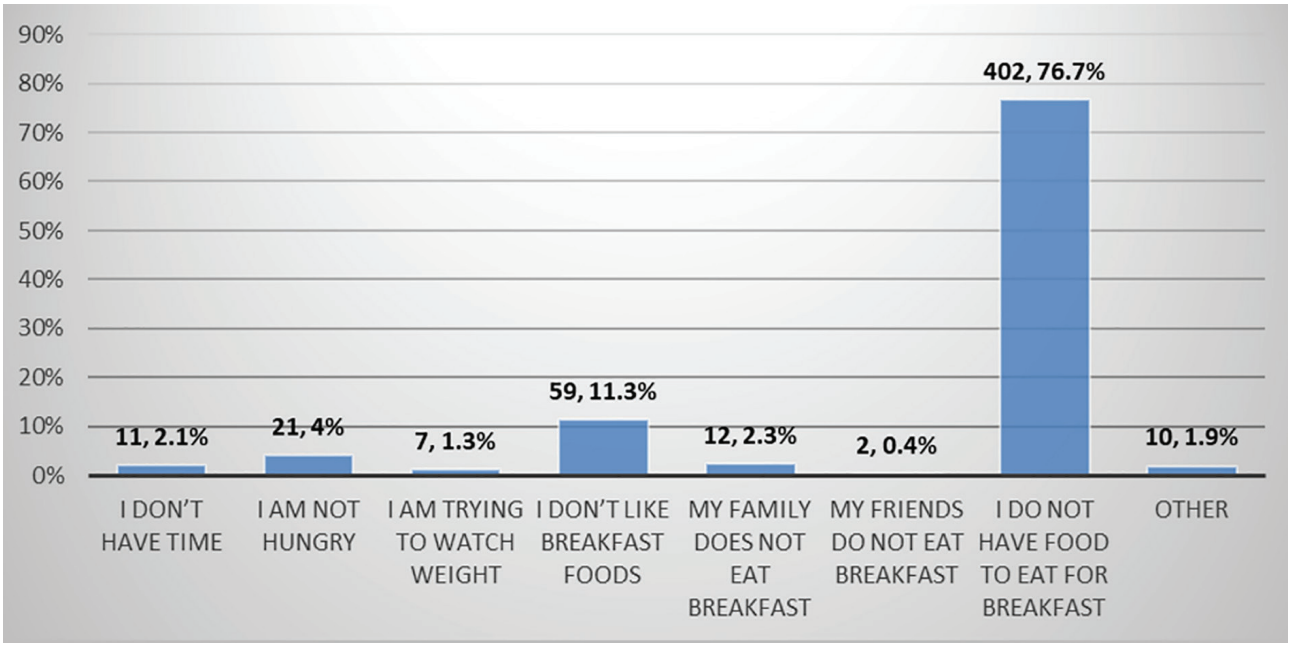

Figure 3: Reasons behind skipping breakfast among students. A significantly higher proportion were compared to other reasons (p<0.001). Comparing the students' disliked eating breakfast with those who did not want to eat during recess (p=0.02). The students were influenced by their family and friends' eating habits (p=0.05).

Table 3: Types of breakfast eaten by students.

Variable	Number	%
Checklist (N=547)		
Bread with bean	17	4
Bread with bean+artificial juice	3	1
Bread with bean+milk tea with biscuit	50	9
Bread with bean+milk with biscuit	13	2
Bread with bean+natural juice	1	0.2
Bread with milk+biscuit	4	1
Bread with cheese	1	0.2
Bread with cheese+milk tea with biscuit	4	1.2
Bread with cheese+milk with biscuit	1	0.2
Bread with egg+artificial juice	1	0.2
Bread with egg+milk tea with biscuit	4	1.2
Bread with tahnia+milk tea with biscuit	3	1
Bread with tahnia+milk with biscuit	1	0.2
Bread with tameia	55	10
Bread with tameia+artificial juice	14	3
Bread with tameia+bread with bean	10	2
Bread with tameia+bread with bean+milk tea with biscuit	8	1
Bread with tameia+bread with cheese	8	1
Bread with tameia+bread with egg	5	1
Bread with tameia+bread with honey	2	0.4
Bread with tameia+bread with jam	3	1
Bread with tameia+bread with tahnia	6	1
Bread with tameia+milk tea with biscuit	283	52
Bread with tameia+milk with biscuit	28	5
Bread with tameia+natural juice	12	2
Bread with tameia+soft drink	1	0.2
Milk tea with biscuit	7	1
Milk with biscuit	1	0.2
Natural juice	1	0.2

The combination of bread with tameia and milk tea accompanied by biscuits (p<0.001).

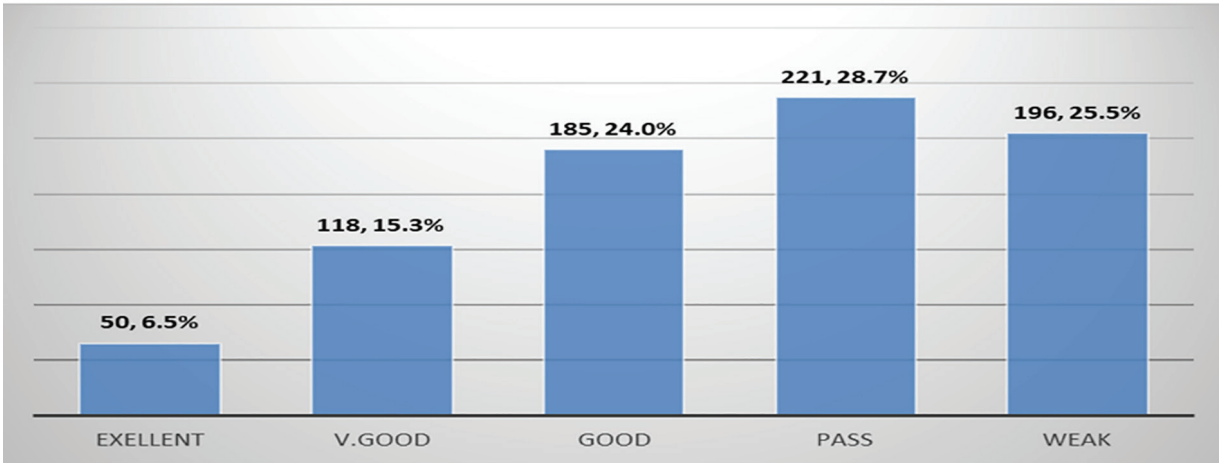

Figure 4: School performance among students (n=770). Students who skipped breakfast were significantly more in 'weak' performance group (p=0.001). Inadequate energy intake was associated with increase in 'fail' category (p=0.021).

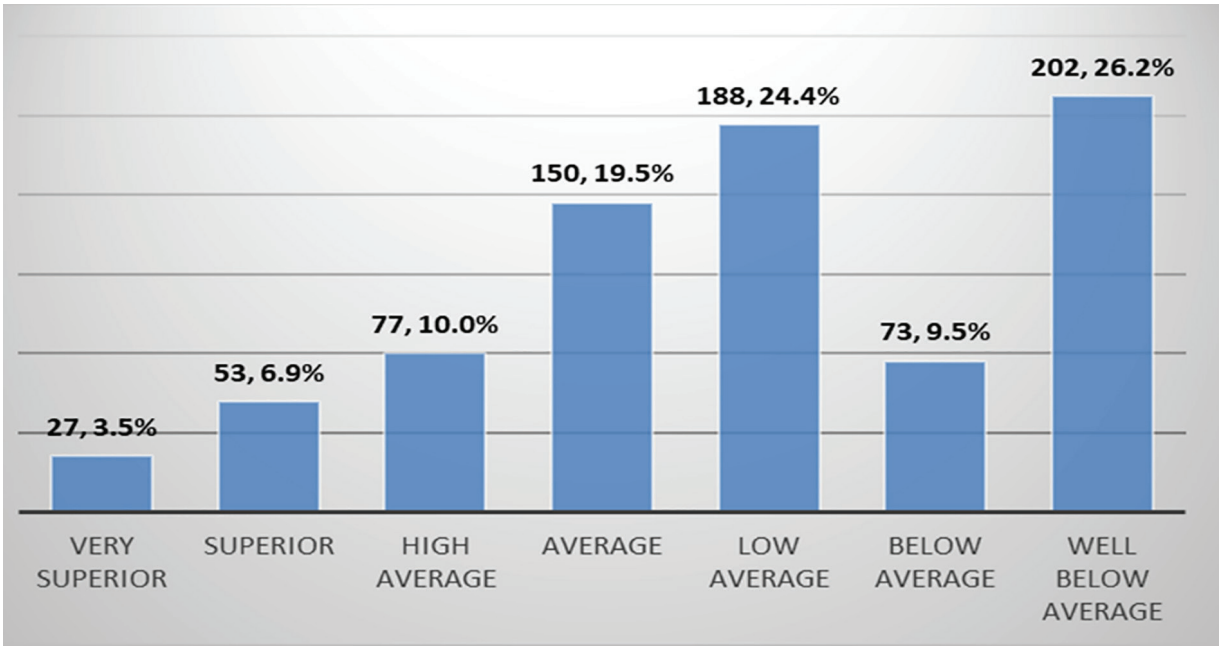

Figure 5: The cognitive ability of the students (n=770). Students who skipped breakfast scored significantly lower cognitive (p<0.00).

Figure 4 shows that 28.7% of students achieved the pass level, 25.5% had weak performance at school, 24% were good, 15.3% were very good and 6.5% achieved excellent grades at school. Multinomial logistic regression revealed that students who skipped breakfast were significantly more likely to be in the 'weak' performance group [(OR=2.3, 95%CI [1.5-3.6], (p=0.001)] when compared to the 'good' group. Inadequate energy intake was also associated with increased odds of being in the 'fail' category [(OR=1.8, 95%CI [1.1-2.9], (p=0.021)]. Figure 5 illustrates major differences among the students' cognitive abilities as well as among their habitual eating. Unfortunately, the higher percentage of students (26%) scored below average, and those who scored very superior were only 3.5%. Students who skipped breakfast scored significantly lower cognitive abilities [(t=6.27) (p<0.00)].

Discussion

Nutritional ingredients were shown to play important roles in health status of people (21-23). Previous studies revealed an association between overall/whole dietary composition and many diseases (24, 25). So this research assessed the impact of regular breakfast consumption on the academic performance and cognitive abilities of children aged 6-15 years in government basic schools in Khartoum State, Sudan. However, there is limited evidence supporting the statement that regularly eating breakfast can affect the academic performance and cognitive abilities of children in Sudan within this age group. The participants ranged from six to fifteen years old, with an average age of 12, although some children were older due to delays in school enrollment. It is worth noting that children typically start school at the

age of six years and finish primary education at age 14. Some children were seven years old when they started school, while others were fifteen when they completed the primary level. This is due to challenges that children face in Sudan such as civil war, natural disasters of famine, drought, and desert forming which displace families, and affect children's education and nutritional habits (26).

The findings revealed that most of the families were in poor level with a percentage of 64%. The parents were aware of their child's needs; but found it difficult to fulfill because of their low income. In additions, most parents completed their primary education (56% and 38% of mothers and fathers, respectively) which may affect children nutritional status. Some studies have argued that parents' educational level and occupational status had no significant effect on children nutritional status (27-29). Thus, developing appropriate training courses and nutrition educational programs to enhance mothers' knowledge and attitudes toward children's nutrition is required (29). Furthermore, promoting school feeding programs, implementing effective nutrition interventions, enhancing the school environment, and conducting regular health assessments are essential to ensure the well-being of school children and community. It seems that parents' educational level and occupation may not be the primary factors influencing children's nutritional status (27).

The findings have revealed that 26.4% of children were classified as severely thin and 38.7% were considered as thin. These children had inadequate intake of protein, fat, energy, and carbohydrates, with percentages of 63.2%, 53.6%, 52.6% and 51.2%, respectively. The insufficiency of energy, protein, carbohydrates, and fat in breakfast appears to be influenced by the parents' socio-economic status or/and school nutritional options rather than habitual nutritional reasons. The low-fat intake during breakfast seems to be related to the lack of adequate carbohydrates and energy, as most children do not consume enough fat in their breakfast or skip breakfast altogether (7, 30, 31). These findings align with previous studies addressing the role of energy and carbohydrate intake (7, 30, 31). While the impact of diet on educational achievement is still being studied, there is clear evidence supporting the promotion of physical activity and a diet low in fat, salt, and sugar, but rich in fruits, vegetables, and complex carbohydrates for the overall health of school children (31).

Millions of primary school-age children attend hungry at school in the developing countries, with 23 million in Africa (32). Malnutrition has a detrimental effect on children's health, cognitive development, educational attainment, and overall quality of life (3, 27, 32, 33). A study was conducted in Sudan by Khalid *et al.* reporting a strong association between child malnutrition and children who skipped meals during the school day or brought their food from home (OR 2.744; 95%CI: 2.131-3.532, 1.752; 95% CI: 1.441-2.129, respectively). It is concerning that only 45% of students had daily breakfast, while a significant (43.7%) proportion skipped breakfast altogether. There was a clear need for consistency, with students averaging only twice a week for breakfast. Among breakfast eaters, 44.7% obtained their breakfast from school (27). Several studies shared similar reasons that 76% of students did not bring or could not afford buying food at school, potentially due to low family income (1, 26, 27).

In our study, other reasons to skip breakfast were disliking the meal (11%), lack of appetite during recess (4%), family influence (2.3%), and peer influence (0.4%). The habits and choices of both individuals and society can influence how often children ate breakfast. The most common breakfast for 52% of students was bread with fried chickpeas (tamiea) and milk tea with a biscuit, which lacked sufficient energy, vitamins, and carbohydrates. Only 1% of them included milk in their regular breakfast. Vitamin A deficiency was also noted among those students and 36% of the students had night blindness. A study by the Economic Research Service of the United States, Department of Agriculture stated that children with access to school breakfast had a better overall diet and consumed less fat, and more magnesium, vitamin C and folate (34).

Another study revealed that vitamin A deficiency posed a major public health challenge in Sudan and the diet provided to the children at schools was mostly nutritionally deficient in vitamin A (35). They found that children aged 5 years and older had higher vitamin A deficiency. Parents' understanding of the critical role of vitamin A, as well as the risks of deficiency and prevention strategies, directly impacted children's health (35). Other researchers indicated that children who participated at school breakfast plan ate more fruits, drank more milk, and consumed a wider variety of foods. To ensure better mental and physical health for students, it is imperative for the school system to actively support parents in promoting the importance of having a healthy breakfast and access to a healthy diet at school (31, 36).

Many students had breakfast at 10:00 am, with almost half ate it during recess. However, over half of the students delayed breakfast after 10:00 am, and 31.1% ate at home after school time. This delay

can impact students' attention and concentration. Notably, 41.4% of students believed breakfast to provide them energy and positively impact their physical performance. This belief was particularly strong among students who were negatively affected by skipping breakfast. It was shown that students had varying opinions on the benefits of breakfast, such as improved focus, better grades, attentiveness, and mood, which were essential for academic performance (3, 7, 27, 32, 37). There were significant differences in students' cognitive abilities and eating habits. Unfortunately, 26% of students scored well below average, and only 3.5% scored very superior. Several studies showed that eating breakfast had a positive effect on children's cognitive performance, particularly for memory and attention (37-40). This study provided compelling evidence that breakfast consumption significantly influenced children's performance and cognitive abilities.

Conclusion

Most school-age children in primary schools across Khartoum State, Sudan did not follow consistent or sustainable breakfast habits and they skipped breakfast on most weekdays. No clear correlation was found between having or skipping breakfast and parents' educational level. The financial status of the family stands as a primary factor that may prevent children from having a healthy breakfast at school. To enhance breakfast habits among primary school children in Khartoum State, there is a need to implement a multifaceted approach. This could involve school-based breakfast programs, increasing awareness, collaborating with local organizations for funding, and regularly evaluating effectiveness to make necessary adjustments.

Acknowledgement

All authors express gratitude to the study participants. Special thanks to the School Health Team and the Ministry of Health in Khartoum state.

Funding

No funding was received.

Authors' Contribution

BA participated in formulating the research question for this article, collected and analyzed the studies, and prepared the draft of the review. SM formulated the topic, assisted in developing the research question, supported the research design, analyzed and critically reviewed the included studies, and edited and refined the completed article. MF updated, integrated, reviewed studies, and edited the final manuscript. ED analyzed and interpreted the findings, while AN and MI reviewed and edited the manuscript.

Conflict of Interest

All authors declare that they have no conflicts of interest.

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