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Breakfast on Cognitive Function and Academic Performance in Adolescents

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Abstract

A regular breakfast contributing approximately 15–30% of total daily energy requirements is essential for adolescent health and cognitive development, including concentration, memory, and mood, which may ultimately enhance learning achievement. This study aimed to examine the effect of breakfast consumption on cognitive function and academic performance among adolescents. A quasi-experimental design was conducted among students from SMPN 1 Ciomas as the intervention group and SMPN 2 Ciomas as the control group, involving 69 participants in each group. The intervention group received a standardized breakfast consisting of rice, balado eggs, fried tofu, stir-fried water spinach, and water, providing 20.2% of daily energy requirements. Breakfast energy intake in the control group was assessed using a food record method. Cognitive function and academic performance were evaluated using the Digit Symbol Substitution Test (DSST) and subject-based assessments in reading comprehension and basic mathematics. The intervention group demonstrated significantly higher blood glucose levels compared with the control group (95.5 ± 9.8 mg/dL vs. 74.8 ± 7.0 mg/dL; p<0.001). Mean cognitive function scores were also significantly higher in the intervention group (62.2 ± 13.8) than in the control group (48.7 ± 13.8; p<0.001). Similarly, academic performance in reading comprehension (75.9 ± 16.7) and basic mathematics (70.9 ± 20.2) was significantly better than that of the control group (68.1 ± 20.4 and 50.0 ± 23.0, respectively; p<0.001). Overall cognitive function scores were also higher in the intervention group (73.4 ± 15.9) compared with the control group (59.0 ± 19.5). These findings indicate that breakfast with appropriate quality and quantity significantly improves blood glucose levels, cognitive function, and academic performance among adolescents.

Introduction

Breakfast is an important part of healthy eating habits for adolescents because it replenishes the body's energy stores after an overnight fast and has been associated with improved nutrient intake (Sebastian *et al.,* 2024). A good breakfast was recommended between waking up and 9:00 a.m. and was expected to meet 15-30% total, both macro and micronutrients, for optimal metabolic function (Sebastian *et al.,* 2024). Globally, approximately 10–30% of children and adolescents skip breakfast, indicating that skipping breakfast is quite common. Skipping breakfast (eating breakfast <5 times/week) was associated with lower average school grades (Boschloo *et al.*, 2012). Breakfast was also associated with adolescents' long-term nutritional status, so skipping breakfast could disrupt it. There was a link between skipping breakfast and unhealthy

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eating patterns, such as excessive consumption of high-sugar and high-energy foods during the day and evening, which could increase the risk of overnutrition (López-Gil *et al.*, 2022). Furthermore, this habit was often associated with excessive late-night snacking, which contributed to an increase in body mass index and further exacerbated the habit of skipping breakfast (Karatzi *et al.*, 2017). A meta-analysis by Ma *et al.* showed that skipping breakfast could increase the risk of obesity (Ma *et al.*, 2020).

Breakfast not only supported nutritional status but also had a significant relationship with students' cognitive development and academic performance. Breakfast supported cognitive function, especially memory and concentration, by maintaining stable blood glucose levels (Edefonti *et al.*, 2014). To concentrate well, adolescents' brains require energy in the form of glucose, which is a byproduct of digesting the food consumed previously, namely at breakfast. A study by Benton *et al.* found that adequate breakfast intake increased learning motivation and made people feel full longer than skipping breakfast (Benton *et al.*, 2001). According to a study in Chile, adolescents who consumed a high-quality breakfast before performing cognitive tasks performed better than adolescents who skipped breakfast or did not consume a proper breakfast (Peña-Jorquera *et al.*, 2021).

Good, regular breakfast habits were also closely related to higher learning motivation and significantly improved academic achievement, serving as a mediator between breakfast consumption and academic performance (Gao *et al.*, 2021; Martin *et al.*, 2024; Lundqvist, 2019). This confirmed the importance of breakfast in supporting students' physical and mental health (Gao *et al.*, 2021). Conversely, skipping breakfast could negatively impact cognitive performance. Students who skipped meals often felt more tired and less focused during learning activities, which reduced learning effectiveness and had long-term impacts on students' learning abilities (Ugwunne *et al.*, 2024).

Various studies on breakfast demonstrated its importance for cognitive development and academic performance. However, research on this topic remained limited and inconsistent, warranting further, comprehensive investigation (Peña-Jorquera *et al.*, 2021). Therefore, interventions, education, and motivation enhancement are needed to promote healthy breakfast habits among students, as breakfast not only contributes to meeting nutritional requirements but also plays a crucial role in fostering mental readiness and supporting academic achievement (Harris *et al.,* 2021; Martin *et al.,* 2024).

Blood glucose levels result from the breakdown of complex carbohydrates in the digestive system, providing energy for cognitive functions such as memory, concentration, and other brain functions (Hoyland *et al.*, 2008; Scholey *et al.*, 2020; Khairiyah *et al.*, 2022). Several previous studies showed that providing snacks and other foods such as buras (rice, rice, and noodles), and good breakfast habits, among schoolchildren, significantly impacted blood glucose levels and short-term memory (STM), particularly in recalling words and images (Kustiyah & Kusprasetia, 2018; Kustiyah *et al.*, 2020; Rachman *et al.,* 2026). Furthermore, a breakfast with good quality and quantity could improve academic performance. A better nutrient composition can improve blood glucose levels and SSM compared to a breakfast with a less good composition. Goldberg *et al.* added that adequate nutrition was important for maintaining basic executive abilities (Goldberg *et al.*, 2019). This was aligned with the results of a study by Adolphus *et al.*, which showed that breakfast contributes to cognitive function and academic performance (Adolphus *et al.*, 2015). This study attempts to address the limitations and inconsistencies of previous studies by conducting a comprehensive analysis using a measured breakfast intervention to validate its significant association with improved cognitive function and academic performance in adolescents. Therefore, this study analysed the effect of breakfast interventions on cognitive function and academic performance in adolescents.

Method

This study used a quasi-experimental design with a control group to examine the effect of breakfast on blood glucose levels, cognitive function, and academic performance. Two junior high schools in Bogor Regency were selected using purposive sampling based on the number of students who met the criteria and the schools' permission. The study consisted of two groups: an intervention group (IG) that received breakfast according to the Balanced Nutrition Guidelines and a control group (CG) that was free to eat breakfast as they normally did. Schools were randomly allocated to the intervention and control groups. This study was approved by the IPB University Human Ethics Commission under Number 1850/IT3. KEPMSM-IPB/SK/2025.

Subject selection from the study population was based on inclusion and exclusion criteria. The inclusion criteria for subjects were 8th-grade junior high school students, no history of diabetes mellitus, willingness to participate as evidenced by informed consent, and permission from their parents/guardians. Exclusion criteria included breakfast at home for the intervention group. As breakfast was provided at school, or no breakfast at home for the control group, they followed a specific diet program, and/or participated in activities/ competitions. The number of subjects was calculated using the Sastroasmoro and Ismael formula, with an anticipated 25% dropout rate (Sastroasmoro & Ismael, 2014). Thus, the number of subjects per group was 50, resulting in a total of 100 subjects. The study included 138 subjects, with 69 in each IG and 69 in the CG. A flowchart of the subject recruitment procedure was presented in Figure 1.

The intervention in this study was giving breakfast to students, with three meals per group. This study consisted of several stages: screening, determining and dividing the IG and CG, collecting data on subject and family characteristics, food consumption, administering the intervention, and measuring blood glucose levels, cognitive function, and academic performance.

The IG was provided with a complete breakfast composition each week according to the PGS, which met 15-30% of daily nutritional needs. The IG had breakfast days (BD) and no-breakfast days (NBD). On the BD, IG subjects were instructed not to eat breakfast at home because they would be having breakfast together at school. Before breakfast, subjects filled out a food record, guided by an enumerator, to ensure they did not eat breakfast at home. Afterwards, subjects were directed to have their blood glucose measured before breakfast, followed by cognitive function, and to assess academic performance. Then, the IG received breakfast according to the PGS. During the one-hour waiting period between breakfast together and the blood glucose measurement, the enumerator conducted a food recall interview. Next, blood glucose measurements were taken after breakfast, followed by cognitive function and academic performance assessments, and concluded with another food recall interview if not completed beforehand. On the NBD, CG subjects did not receive breakfast and were free to eat breakfast at home according to their individual habits. Upon arrival at school, subjects were immediately directed to fill out a food record, followed by a blood glucose measurement after breakfast. Afterwards, cognitive function and academic performance were measured after breakfast, and were concluded with a food recall interview. Subjects in the CG received a breakfast meal or breakfast substitute after data collection was completed during each HTS. Rewards were given to all subjects in the IG and CG after data collection

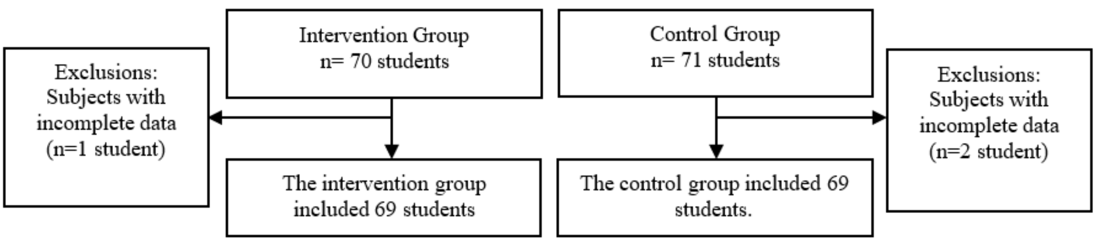

Figure 1. Flowchart of the Subject Recruitment Procedure

was completed.

The data collected included primary and secondary data. Primary data included subject and family characteristics, blood glucose levels, breakfast intake, and cognitive function and academic performance. Subject characteristics included age, gender, and pocket money. Family characteristics included parents' highest level of education, occupation, and income, as well as the number of family members. Blood samples were drawn using the finger-prick method, and blood glucose levels were measured using an Accu-Chek Active glucometer. Breakfast intake was estimated from interviews using a breakfast-habits questionnaire and food records to determine whether subjects ate breakfast at home.

Cognitive function data were measured using the Digit Symbol Substitution Test (DSST) (Weschler, 2008). The DSST involved matching numbers to symbols using an answer key within a 90-second time limit. Cognitive function data were collected using a structured questionnaire comprising 99 boxes. Academic performance in this study was estimated using standardised academic test results, reading comprehension, and basic mathematics. Academic performance was measured using a structured questionnaire comprising 5 short-reading texts and 10 math operations questions. Cognitive function and academic performance were assessed by assigning a score of 1 for each correct answer and a score of 0 for each incorrect answer. The maximum score range for each instrument was 100 for the DSST, 5 for reading comprehension, and 10 for basic mathematics. The cognitive function and academic performance questionnaires

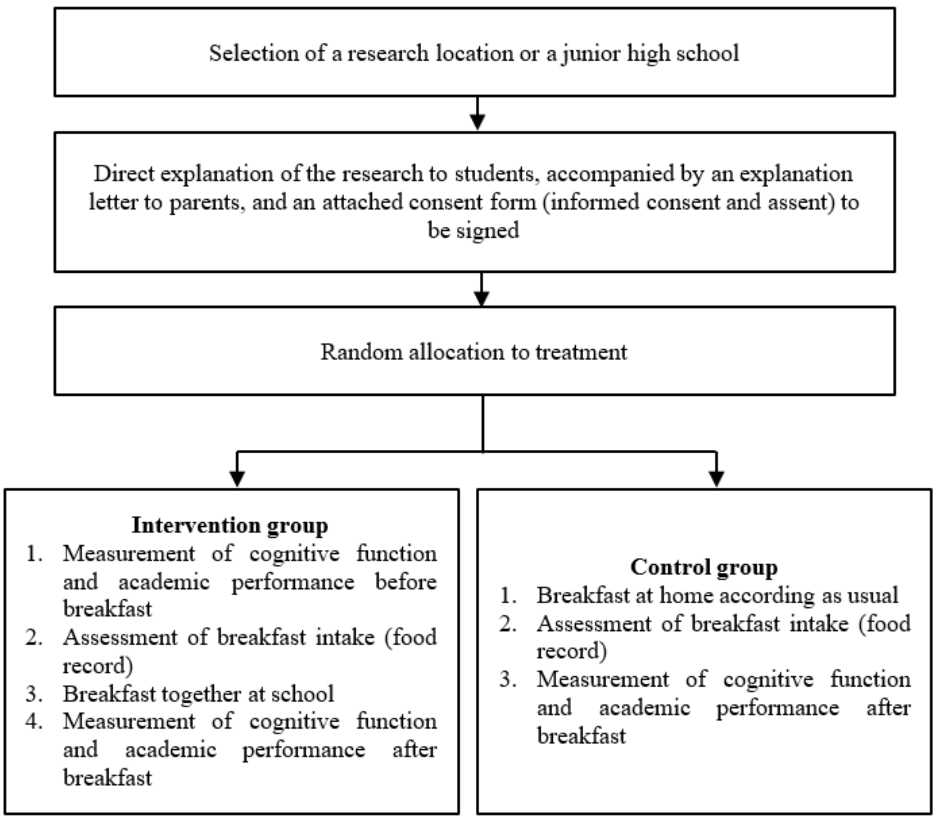

Figure 2. Research stages in the Intervention and CG

were pilot-tested and were found to be valid and reliable, with Cronbach's-alpha values of 0.961, 0.857, and 0.698 for the DSST, basic mathematics, and reading comprehension, respectively. Academic performance was calculated as the average of scores in basic mathematics and reading comprehension.

Data processing included entry, editing, coding, and cleaning. Data processing was performed using Microsoft Excel 2021 and SPSS version 16.0 for Windows. Data analysis was conducted to analyse the distribution and differences in subject and family characteristics, blood glucose levels, cognitive function, and academic performance. Furthermore, differences in subject characteristics, family socioeconomic and demographic characteristics, average blood glucose levels, cognitive function, and academic performance of adolescents between the IG and CG were analysed using the Mann-Whitney U Test.

Result and Discussion

Based on Table 1, the gender distribution in the IG and CG was relatively balanced. 43.5% of subjects in the IG were male, and 56.5% were female, whereas in the CG, the proportions were 46.4% male and 53.6% female. Statistical tests showed no significant difference between the two groups (p=0.733), indicating that the gender characteristics were homogeneous. The age distribution of the subjects was also relatively homogeneous, with mostly 13-year-olds, namely 72.5% in the IG and 73.9% in the CG. The average age in both groups was 13 years. The results of the difference test showed no significant difference in age (p=0.886), indicating that the two groups had comparable age distributions. The distribution of subject characteristics was presented in Table 1.

The characteristics of pocket money showed that approximately half of the subjects were in the high category (≥Rp 15,000), namely 46.4% in the IG and 55.1% in the CG, followed by the low category (≤Rp 10,000), at 46.4% and 39.1%, respectively. The average pocket money in the CG (Rp 14,043) was higher than in the IG (Rp 12,985), but this difference was not statistically significant (p=0.394). Overall, these results indicated that the baseline characteristics

Table 1. Subject Characteristics

Characteristics	Intervention Group (n=69)		Control Group (n=69)		Total (n=138)		p-value
	n	%	n	%	n	%	
Gender							
Male	30	43.5	32	46,4	62	44.9	0.733
Female	39	56.5	37	53,6	76	55.1	
Age (years)							
12	2	2.9	1	1,4	3	2.2	0.886
13	50	72.5	51	73,9	101	73.2	
14	17	24.6	17	24,6	34	24.6	
Mean ± SD	13 years ± 0.48		13 years ± 0.45		13 years ± 0.47		
Pocket Money (Rupiah/day)							
Low (≤Rp. 10000)	32	46.4	27	39,1	59	42.8	0.394
Middle (>Rp. 10000 – Rp. 14000)	5	7.2	4	5,8	9	6.5	
High (≥Rp. 15000)	32	46.4	38	55,1	70	50.7	
Mean ± SD	Rp. 12985 ± Rp. 4292.6		Rp. 14043 ± Rp. 5854.7		Rp. 13514 ± Rp. 5142.1		

Note:
Difference Test Analysis using Mann Whitney U Test

of the subjects in both groups were relatively homogeneous, making them suitable for comparison in analyzing the effect of breakfast provision on blood glucose, cognitive function, and academic performance.

During adolescence, many individuals began to receive pocket money to make more independent food purchases. These independent food choices increasingly contributed to overall dietary quality. Previous research on adolescents aged 11–18 attending secondary schools or colleges in Hampshire, England, showed that 39% reported that their food and beverage purchases, particularly snacks, were less healthy than those for main meals. Adolescents who purchased less healthy foods tended to have poorer diet quality. A stronger association was observed between poorer diet quality and lower socioeconomic status (SES) among adolescents (Shaw *et al.*, 2025).

An analysis of the socioeconomic and demographic characteristics of the subjects' families, presented in Table 2, showed that fathers' educational levels were similar across groups, with the majority having a high school diploma or equivalent: 39.1% in the IG and 40.6% in the CG. There was no significant difference in fathers' education between the two groups (p=0.925). Maternal education levels also showed a similar pattern, with the largest proportion having a primary school diploma or equivalent, with 46.4% in the IG and 33.3% in the CG. However, this difference was not statistically significant (p=0.540).

Approximately three-quarters of the fathers worked as labourers/farmers, both in the IG (60.9%) and the CG (62.3%). No significant difference between the two groups (p=0.907). Meanwhile, more than 80% of mothers were homemakers, at 88.4% in both groups, with the difference also not significant (p=0.985). Most subjects' family sizes were in the medium range (4–6 people), at 81.2% in the IG and 76.8% in the CG, with an average family size of approximately 5 people. There was no significant difference in family size between the groups (p=0.102). Most families' income per capita was classified as poor, at 62.5% in the IG and 59.4% in the CG. Average per capita income in the CG tended to be higher than in the IG, but the difference was not significant (p=0.267).

Family socioeconomic factors, particularly household income and parental education, were associated with the quality of adolescents' dietary patterns. Adolescents from low-income families tended to have poorer dietary quality, characterized by lower consumption of fruits, vegetables, and fibre and higher intake of added sugars and sugar-sweetened beverages. This condition was also associated with limited access to healthy food and a tendency to choose low-cost, energy-dense foods. Parental education also played a significant role in shaping adolescents' dietary environments and habits. Parents with higher levels of education generally had better nutritional knowledge, reflected in feeding practices that encouraged fruit and vegetable consumption and limited the intake of processed foods high in energy and sugar. Conversely, lower parental education levels were often associated with poor adolescent dietary patterns, including higher consumption of sugar-sweetened beverages and lower overall diet quality (Nagata *et al.*, 2025).

However, the socioeconomic and demographic characteristics of families in this study were relatively homogeneous between the IG and CG. This suggested that both groups had comparable socioeconomic backgrounds, indicating that differences in outcomes for blood glucose, cognitive function, and academic performance were more likely attributable to the breakfast intervention than to confounding factors of family characteristics. The distribution of families' socioeconomic and demographic characteristics was presented in Table 2.

Based on Table 3, there was a significant difference in blood glucose levels between the IG and CG (p<0.001). This showed that the average blood glucose level after breakfast in the IG was higher (95.5±9.8) than in the CG (74.8±7.0). In addition, there was also a significant difference in blood glucose levels before and after the breakfast intervention in the IG (p<0.001). This showed that there was an increase in the average blood glucose level from before (76.0±7.2) to after (95.5±9.8) breakfast. The distribution of subjects by blood glucose

Table 2. Socioeconomic and Demographic Characteristics of the Family

Characteristics	Intervention Group (n=69)		Control Group (n=69)		Total (n=138)		p-value
	n	%	n	%	n	%	
Fathers Education Level							
No Education	0	0	0	0	0	0	
Elementary School	24	34.8	22	31.9	46	33.3	
Junior High School	9	13.0	12	17.4	21	15.2	0.925
Senior High School	27	39.1	28	40.6	55	39.9	
Academy/College	9	13.0	7	10.1	16	11.6	
Mothers Education Level							
No Education	0	0	0	0	0	0	
Elementary School	32	46.4	23	33.3	55	39.9	
Junior High School	8	11.6	18	26.1	26	18.8	0.540
Senior High School	21	30.4	22	31.9	43	31.2	
Academy/College	8	11.6	6	8.7	14	10.1	
Fathers Occupation							
Not working	4	5.8	4	5.8	8	5.8	
Civil servant/Armed Forces/ Police officer	4	5.8	4	5.8	8	5.8	
Private employee	7	10.1	7	10.1	14	10.1	0.907
Self-employed	6	8.7	5	7.2	11	8	
Laborer/farmer	42	60.9	43	62.3	85	61.6	
Other	6	8.7	6	8.7	12	8.7	
Mothers Occupation							
Housewife	61	88.4	61	88.4	122	88.4	
Civil servant/Armed Forces/ Police officer	2	2.9	2	2.9	4	2.9	
Private employee	3	4.3	0	0	3	2.2	0.985
Self-employed	0	0	1	1.4	1	0.7	
Laborer/farmer	1	1.4	5	7.2	6	4.3	
Other	2	2.9	0	0	2	1.4	
Family Size							
Small (1-3 peoples)	4	5.8	11	15.9	15	10.9	
Medium (4-6 peoples)	56	81.2	53	76.8	109	79.0	0.102
Large (>6 peoples)	9	13.0	5	7.2	14	10.1	
Mean ± SD	5 peoples ± 1,3		5 peoples ± 1.2		5 peoples ± 1.3		

Income per Capita							
Poor (<Rp 582,932)	45	62.5	41	59.4	86	62.3	0.267
Vulnerable to Poverty (Rp 582,932 – Rp 847,398)	15	21.7	11	15.9	26	18.8	
Towards Middle Class (Rp 874,398 – Rp 2,040,262)	8	11.8	14	20.3	22	15.9	
Middle Class (Rp 2,040,262 – Rp 9,909,844)	1	1.4	3	4.3	4	2.9	
Upper Class (>Rp 9,909,844)	0	0	0	0	0	0	
Mean ± SD	Rp. 576376 ± Rp. 457890.5		Rp. 700904 ± Rp.614268.6		Rp. 638640 ± Rp.543376.1		

Note:
Difference Test Analysis using Mann Whitney U Test

Table 3. Distribution of Subjects Based on Blood Glucose Levels in the Intervention and Control Groups

Parameter	Intervention Group	Control Group	*p-value*
	Mean ± SD		
Blood Glucose Level (mg/dL)	95.5 ± 9.8	74.8 ± 7.0	<0.001**

Note:
Difference Test Analysis using Mann Whitney U Test
** Significant with p-value <0.001

level in the IG and CG was presented in Table 3.

Blood glucose levels in the IG were significantly higher than those in the CG. This was due to the subjects consuming a breakfast that met balanced nutrition guidelines (carbohydrates, animal protein, vegetable protein, and vegetables), which contributed 20.2% to the energy requirement. In contrast, the CG tended to have a breakfast that was dominated by carbohydrates and animal or vegetable protein, with an average energy requirement of 10.4%. The difference in breakfast composition between the KI and KK groups resulted in differences in average or variation in blood glucose levels. Therefore, the composition (type) and timing of breakfast played a crucial role in ensuring glucose availability for the brain (Edefonti *et al.*, 2014; Kustiyah *et al.,* 2020; Aznar *et al.*, 2021).

The increase in blood glucose levels, particularly in KI, was due to the integrated metabolic processes of nutrients such as carbohydrates, protein, and fat. The primary nutrient-metabolism process that ensured blood glucose availability was the breakdown of complex carbohydrates into simple carbohydrates, namely glucose. Glucose was converted into energy (ATP) through glycolysis and the citric acid cycle. However, fat and protein could also be converted to glucose through beta-oxidation and deamination (Scholey *et al.*, 2001; Messier, 2004; Knight *et al.*, 2014; Nimgampalle *et al.*, 2021). Functionally, stable glucose levels were crucial for supporting the activity of neurotransmitters such as acetylcholine, serotonin, and noradrenaline, which played a vital role in memory consolidation, modulation, motivation, and attention (Bai *et al.*, 2024). A breakfast containing a combination of carbohydrates, protein, and fat can provide more stable and sustained glucose availability compared to carbohydrate-only intake. Therefore, a recommended breakfast consisted of a source of complex carbohydrates, fat, and protein to slow down the metabolic or digestive processes, so that blood glucose levels

Table 4. Distribution of Subjects Based on Cognitive Function and Academic Performance in the Intervention and Control Groups

Parameters	Intervention Group	Control Group	p-value
	Mean ± SD		
Cognitive Function			
Digit Symbol Substitution Test (DSST)	62.2 ± 13.8	48.7 ± 13.8	<0.001**
Academic Performance			
Reading Comprehension	75.9 ± 16.7	68.1 ± 20.4	0.023*
Basic Mathematics	70.9 ± 20.2	50.0 ± 23.0	<0.001**
Academic Performance	73.4 ± 15.9	59.0 ± 19.5	<0.001**

Note:
Difference Test Analysis using Mann Whitney U Test
* Significant with p-value <0.05
** Significant with p-value <0.001

increased slowly and blood glucose availability could be maintained stably for up to 2 hours after consumption (Wilson *et al.,* 2018; Gaylor *et al.*, 2022).

Table 4 presents the comparison results for cognitive function and academic performance between the intervention and CG, with 69 subjects in each group. In terms of cognitive function, as measured by the Digit Symbol Substitution Test (DSST), the IG had an average score of 62.2 ± 13.8, while the CG is 48.7±13.8 with a p-value of <0.001. This indicated a statistically significant difference between the two groups, with the IG demonstrating better cognitive function. The results of this study demonstrated that a high-quality breakfast with a balanced nutritional profile could improve cognitive function. These results aligned with those of Baharuddin *et al*., who found that a good breakfast could improve cognitive function (Baharuddin *et al.*, 2025).

Academic performance was measured using three areas: reading comprehension, and basic mathematics. The reading comprehension score in the IG (75.9 ± 16.7) was higher than the CG (68.1 ± 20.4); the test results showed that there is a significant difference between the two groups with p-value <0.05 (p-value = 0.023). In basic mathematics, the IG score (70.9 ± 20.2) was also higher than the CG score (50.0 ± 23.0) with a p-value <0.001. Judging from the average academic performance scores (reading comprehension and basic mathematics), the IG had a higher average score (73.4 ± 15.9) than the CG (59.0 ± 19.5), and the t-test showed a significant difference between the two groups (p-value <0.001). Overall, Table 4 showed that the average cognitive function and academic performance test scores in the IG were higher and significantly different from those in the CG.

Cognitive function encompasses complex mental processes, including memory, reasoning, and problem-solving, and is influenced by various physiological factors such as nutritional status and overall body condition (Carey *et al.,* 2024; Yeh *et al.,* 2025). According to cognitive psychology, the availability of nutrients from breakfast was crucial because it provided glucose, the brain's primary energy source. An adequate morning intake ensured neural readiness for intensive mental activity. Thus supporting concentration and the speed of information processing required in a learning environment (Martin *et al*., 2024).

In academic settings, executive function and working memory were key drivers of mastery in literacy and numeracy. In reading comprehension, these processes aided retention and integration of meaningful information, while in basic mathematics, they supported sequential calculations and analytical, logistical reasoning. Optimal neurocognitive processes enabled students to manage complex information loads and solve academic problems more efficiently in the classroom (Spiegel *et al.*, 2021).

Biologically, breakfast habits and improved cognitive performance could be thoroughly explored through neurocognitive mechanisms, particularly in the context of cerebral glucose regulation. As a metabolically active organ, the brain relies heavily on glucose as its primary energy substrate for its vital functions (Liu *et al.*, 2025). A stable supply of glucose in the bloodstream was a prerequisite for efficient neuronal activity and optimal neurotransmitter synthesis, both of which were fundamental to thought processes and memory (Bai *et al.*, 2024). Overnight fasting during sleep naturally caused a drop in blood glucose levels and depletion of liver glycogen reserves. If this energy deficit was not compensated for immediately in the morning, the brain experienced a limited fuel supply for high-level cognitive processes (Chechko *et al.*, 2015; Brocchi *et al.*, 2022). Eating breakfast helped restore blood glucose levels to homeostasis, which directly supported oxidative metabolism in the brain. This not only restored mental alertness but also optimised tension, information processing speed, and memory retention during early-morning learning activities (Tang *et al.*, 2017; Baharuddin *et al.*, 2025).

The results of this study demonstrated that a good and regular breakfast could improve students' academic performance. This finding was relevant to the research of Gayathri *et al.* and Arista *et al.*, which demonstrated that good breakfast habits could improve academic performance (Arista *et al.*, 2025; Gayathri *et al.*, 2025). Academic performance was understood as learning outcomes or academic achievement, reflecting the extent to which learning objectives were achieved, as measured through formal evaluations such as tests, assignments, and exams. Academic performance was closely related to breakfast because the brain required energy (glucose) to perform cognitive functions. Eating breakfast provides the brain with energy to perform cognitive functions, thereby improving academic performance.

Conclusion

Blood glucose levels in the IG were significantly higher and significantly different from those in the CG. The average cognitive function and academic performance test scores in the IG were also higher and significantly different from those in the CG. A well-considered breakfast could positively impact blood glucose levels, cognitive function, and academic performance. The importance of breakfast quantity and quality in supporting cognitive function suggests that targeted nutritional interventions could enhance cognitive function and improve academic performance in adolescents. A nutritious breakfast program in schools to improve blood glucose, cognitive function, and academic performance could be implemented through nutrition education for students and parents about the importance of a complete and balanced breakfast, followed by strengthening school policies related to the provision of healthy food and cafeteria supervision, and mentoring adolescents in developing healthy and balanced breakfast habits. Furthermore, advanced research was needed to expand the scope to anticipate variations between schools.

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