



IMPACT OF BREAKFAST SKIPPING ON CONCENTRATION AND ACADEMIC PERFORMANCE AMONG MIDDLE AND HIGH SCHOOL STUDENTS: A CROSS-SECTIONAL STUDY

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Abstract

Introduction: Breakfast consumption represents a critical determinant of cognitive function and academic achievement among adolescents. Despite its recognized importance, breakfast skipping remains prevalent among school-aged children. This study aimed to assess the prevalence of breakfast skipping and examine its association with concentration levels and academic scores among middle and high school students.

Methods: A school-based cross-sectional study was conducted among 220 students aged 11-18 years at JIET Medical College and Hospital from January to June 2025. Multistage stratified random sampling was employed for participant recruitment. Data were collected through structured questionnaires assessing breakfast consumption patterns, standardized neuropsychological tests (Digit Span Test, Stroop Test, Trail Making Test) measuring concentration, and academic performance records. Statistical analysis included chi-square tests, ANOVA, and multivariate linear regression.

Results: Overall, 56.4% of students engaged in breakfast skipping, with 20.9% classified as frequent skippers. Regular breakfast consumers demonstrated significantly superior concentration performance across all cognitive domains compared to frequent skippers ($p<0.001$). Mean overall GPA was 76.4% among regular consumers versus 66.2% among frequent skippers ($p<0.001$), with consistent patterns across all core subjects. Multivariate regression confirmed breakfast consumption as an independent predictor of academic performance ($\beta=0.326$, $p<0.001$) after controlling for socioeconomic status, parental education, and sleep duration. The model explained 52.4% of variance in academic achievement.

Conclusion: Breakfast skipping is highly prevalent and significantly associated with impaired concentration and reduced academic performance. These findings underscore the urgent need for comprehensive school-based and family-centered interventions promoting breakfast consumption to optimize cognitive function and educational outcomes among adolescents.

Keywords: Breakfast skipping, academic performance, concentration, cognitive function, adolescent health

Introduction

Breakfast, often referred to as the most important meal of the day, represents the first nutritional intake after the prolonged overnight fast and serves as a critical determinant of daily nutritional status, cognitive functioning, and academic performance among school-aged children and adolescents. The consumption of breakfast provides essential nutrients and energy required for optimal brain function, with glucose serving as the primary fuel source for neural activity. The developing brain of children and adolescents demonstrates particularly high metabolic demands, with average cerebral blood flow and oxygen utilization rates being 1.8 and 1.3 times higher respectively compared to adults (Adolphus et al., 2013). Given these elevated metabolic requirements coupled with the extended overnight fasting period resulting from longer sleep durations in youth, breakfast consumption becomes especially vital for maintaining adequate energy supply throughout the morning hours when most academic instruction occurs.

Despite the widely recognized nutritional and physiological importance of breakfast, breakfast skipping has emerged as a prevalent dietary behavior among adolescents globally, with estimates suggesting that between 20-30% of children and adolescents in developed countries regularly skip this critical meal (Adolphus et al., 2013). This proportion increases substantially with age, with older adolescents demonstrating higher rates of breakfast omission compared to younger children. A recent analysis from the United States Youth Risk Behavior Survey documented that a significant proportion of high school students report skipping breakfast, with variations across demographic subgroups including sex, race, ethnicity, and socioeconomic status (Sliwa et al., 2024). In low and middle-income countries, the prevalence appears even more concerning, with studies from Ethiopia reporting breakfast skipping rates of 38.1% among primary school children (Abebe et al., 2022) and similar investigations identifying comparable patterns across sub-Saharan Africa and South Asia.

The factors contributing to breakfast skipping among adolescents are multifaceted and complex, encompassing individual preferences, family dynamics, time constraints, socioeconomic circumstances, and lifestyle patterns. Adolescents frequently cite lack of time in the morning, not feeling hungry upon waking, desire to sleep longer, concerns about body weight, and unavailability of preferred foods as primary reasons for breakfast omission. Parental and household factors play crucial roles, with lower parental education, reduced socioeconomic status, single-parent households, parental employment patterns that necessitate early departures, and inadequate home food availability all emerging as significant predictors of breakfast skipping behavior (Moller et al., 2022). Cultural and geographical variations exist, with urban adolescents often demonstrating higher skipping rates compared to their rural counterparts, and significant differences observed across socioeconomic gradients.

The physiological mechanisms through which breakfast influences cognitive function and academic performance have been extensively investigated and are relatively well understood. Following the overnight fast, hepatic glycogen stores become substantially depleted, leading to reduced blood glucose concentrations in the morning. Consumption of breakfast replenishes these glycogen reserves and maintains stable blood glucose levels, which is particularly critical for brain function as glucose represents the brain's primary energy substrate. Adequate glucose availability is essential for optimal neurotransmitter synthesis, particularly acetylcholine, which plays crucial roles in attention, memory formation, and learning processes. Studies employing neuroimaging techniques have demonstrated that breakfast consumption enhances cerebral blood flow and oxygen delivery to brain regions involved in cognitive processing, including the prefrontal cortex responsible for executive functions such as attention, concentration, planning, and decision-making (Hoyland et al., 2009).

Research examining the relationship between breakfast consumption and cognitive performance has yielded compelling evidence supporting breakfast's beneficial effects on multiple domains of cognition. Systematic reviews and meta-analyses have consistently documented that children and adolescents who regularly consume breakfast demonstrate superior performance on tasks assessing attention, concentration, memory, information processing speed, and executive function compared to those who skip breakfast (Hoyland et al., 2009). A population-level study conducted in South

Australia involving over 61,000 students revealed that those who always skipped breakfast reported significantly lower levels of cognitive engagement at school, with effect sizes suggesting meaningful practical significance (Moller et al., 2022). Experimental studies comparing cognitive performance following breakfast consumption versus fasting have demonstrated acute improvements in attention span, vigilance, working memory capacity, and problem-solving abilities within two to four hours post-consumption.

The translation of breakfast-induced cognitive benefits into tangible academic outcomes represents a critical area of investigation with direct implications for educational policy and practice. Cross-sectional studies across diverse geographical and cultural contexts have documented positive associations between habitual breakfast consumption and academic achievement indicators including standardized test scores, teacher-reported academic performance, and cumulative grade point averages. A landmark study from India involving 379 urban middle school children found that students who regularly ate breakfast performed significantly better in mathematics, English, and overall academic scores compared to breakfast skippers (Gajre et al., 2008). Similarly, research from Ethiopia demonstrated that breakfast skipping was independently associated with lower academic achievement even after controlling for confounding variables including socioeconomic status and parental education (Feye et al., 2023). A large-scale investigation from China encompassing over 147,000 primary and middle school students confirmed that more frequent breakfast consumption correlated with improved comprehensive academic performance on standardized assessments.

The mechanisms linking breakfast consumption to enhanced academic performance extend beyond direct cognitive effects to encompass behavioral and motivational pathways. Students who consume breakfast demonstrate improved classroom behavior characterized by increased on-task engagement, reduced disruptive behavior, enhanced attention during instruction, and greater participation in learning activities. These behavioral improvements create a more conducive learning environment and maximize the productive utilization of instructional time. Additionally, breakfast consumption has been linked to enhanced achievement motivation, with students feeling more energized, alert, and ready to engage with academic challenges. The absence of hunger-related distractions allows students to focus mental resources on learning rather than physiological discomfort, thereby optimizing cognitive capacity available for academic pursuits.

From a broader health perspective, regular breakfast consumption contributes to overall dietary quality, increased intake of essential micronutrients including iron, B vitamins, calcium, and vitamin D, maintenance of healthy body weight, and adoption of other positive lifestyle behaviors including physical activity. These holistic health benefits create synergistic effects that collectively support optimal academic functioning. Conversely, chronic breakfast skipping has been associated not only with nutritional inadequacies and elevated obesity risk but also with adverse mental health outcomes including depression, anxiety, and poor emotional well-being, all of which can further compromise academic success.

Given the substantial evidence linking breakfast consumption to cognitive function and academic performance, coupled with the alarming prevalence of breakfast skipping among adolescents, there exists an urgent need for comprehensive research examining this relationship within specific populations and educational contexts. Understanding the magnitude of breakfast skipping, identifying vulnerable subgroups, elucidating local determinants, and quantifying the impact on measurable academic outcomes provides essential evidence for developing targeted interventions and informing educational policy. The present study was designed to address this critical knowledge gap by investigating the impact of breakfast skipping on concentration and academic performance among middle and high school students in a specific institutional context.

The aim of the study is to assess the prevalence of breakfast skipping among middle and high school students and examine its association with concentration levels and academic scores.

Methodology

Study Design

A school-based, cross-sectional, analytical study design.

Study Site

The study was conducted at JIET Medical College and Hospital, located in a metropolitan area serving a diverse student population from various socioeconomic backgrounds.

Study Duration

The data collection was conducted over a six-month period extending from January 2025 to June 2025.

Sampling and Sample Size

A multistage stratified random sampling technique was employed to ensure representative selection of participants across grades, sections, and demographic subgroups. In the first stage, the middle school (grades 6-8) and high school (grades 9-12) divisions were identified as primary sampling units. In the second stage, within each division, individual grades were stratified to ensure proportional representation across the age spectrum. In the third stage, from each selected grade, sections were randomly chosen using computer-generated random numbers. Finally, within selected sections, individual students were systematically sampled, with every third student on the class attendance roster being approached for participation until the desired sample size was achieved from each stratum.

The sample size was calculated using the formula for estimating prevalence in cross-sectional studies: $n = (Z^2 \times p \times q) / d^2$, where Z represents the standard normal variate corresponding to 95% confidence level (1.96), p denotes the anticipated prevalence of breakfast skipping among adolescents (taken as 35% based on previous international literature), q equals $1-p$ (0.65), and d represents the desired absolute precision (taken as 7%). This calculation yielded a minimum required sample size of 180 students. To account for potential non-response, incomplete questionnaires, and to enhance statistical power for subgroup analyses and multivariate modeling, the sample was inflated by 20%, resulting in a final target sample size of 220 students.

Inclusion and Exclusion Criteria

The study included students aged 11-18 years who were enrolled in grades 6 through 12 at JIET Medical College and Hospital, present on the days of data collection, able to comprehend the study questionnaire with or without minimal assistance, and provided both written informed assent along with parental consent. Exclusion criteria were established to minimize confounding and ensure validity of findings: students with diagnosed eating disorders (such as anorexia nervosa or bulimia nervosa) that might independently affect breakfast consumption patterns were excluded, as were those with chronic medical conditions known to influence appetite or cognitive function including diabetes mellitus, thyroid disorders, chronic gastrointestinal diseases, or neurological conditions. Students receiving medications that could affect appetite, cognition, or academic performance (such as stimulants, antipsychotics, or corticosteroids) were excluded. Those with diagnosed learning disabilities or cognitive impairments requiring special education services were excluded as their academic performance might be influenced by factors other than breakfast consumption. Students who had recently transferred to the school (within the past six months) were excluded to ensure availability of standardized academic records for performance assessment. Finally, students who were acutely ill or had been hospitalized within the preceding two weeks were temporarily excluded.

Data Collection Tools and Techniques

A structured, pretested questionnaire was developed incorporating validated instruments and questions adapted from previous research on breakfast behaviors and academic performance. The

questionnaire captured sociodemographic information including age, sex, grade level, type of residence (urban/rural), family structure, parental education and occupation, household income category, and number of siblings. Breakfast consumption patterns were assessed through a detailed food frequency component inquiring about frequency of breakfast consumption during the past week, typical timing of breakfast, location of consumption (home/school/skipped), reasons for skipping when applicable, and types of foods typically consumed. Questions were adapted from validated dietary assessment tools used in adolescent populations, with modifications for local food context.

Academic performance was measured using multiple indicators to provide comprehensive assessment. Cumulative grade point average from the most recent completed academic term was extracted from official school records with appropriate permissions. Subject-specific grades in core academic areas including mathematics, science, language, and social studies were individually recorded. Standardized test scores from institutional or board examinations conducted within the past year were obtained where available. Teacher-reported academic performance using a validated rating scale assessing overall academic achievement, homework completion, class participation, and scholastic aptitude was collected. Self-reported academic performance ratings and academic self-efficacy measures were also obtained from students to capture subjective perspectives on academic functioning.

Data Management and Statistical Analysis

Questionnaires with more than 20% missing data were excluded from analysis. Data were entered into a computerized database using Microsoft Excel with dual entry by independent data entry operators to minimize transcription errors. Data were subsequently imported into IBM SPSS Statistics version 26.0 for comprehensive statistical analysis. Categorical variables such as sex, grade level, breakfast frequency categories (never skip/sometimes skip/always skip), and socioeconomic status categories were presented as frequencies and percentages. Continuous variables including age, concentration test scores, and academic grades were expressed as means with standard deviations or medians with interquartile ranges depending on distribution normality as assessed through the Kolmogorov-Smirnov test. Graphical methods including histograms and Q-Q plots were employed to visually inspect distribution characteristics.

Bivariate analysis was performed to examine associations between breakfast skipping and concentration as well as academic performance outcomes. Chi-square tests were used to assess relationships between categorical variables. Independent t-tests were employed to compare mean concentration scores and academic performance between breakfast consumers and skippers when data met parametric assumptions. A p-value less than 0.05 was considered statistically significant for all analyses. Results were presented through appropriate tables, figures, and graphs to facilitate interpretation and communication of findings.

Ethical Considerations

The study protocol received comprehensive ethical review and approval from the Institutional Ethics Committee of JIET Medical College and Hospital prior to initiation of any data collection activities, ensuring full compliance with ethical principles outlined in the Declaration of Helsinki, Indian Council of Medical Research guidelines for biomedical research on human participants, and institutional policies for research involving minors. Written informed consent was obtained from parents or legal guardians of all potential participants, with consent forms written in clear, simple language explaining study objectives, procedures, voluntary nature of participation, confidentiality protections, and rights including freedom to withdraw at any time without consequences.

Results

Table 1: Sociodemographic Characteristics of Study Participants (N=220)

Characteristic	Category	Frequency (n)	Percentage (%)
Age Group (years)	13-Nov	82	37.3
	14-16	98	44.5
	17-18	40	18.2
Gender	Male	112	50.9
	Female	108	49.1
Grade Level	Middle School (6-8)	94	42.7
	High School (9-12)	126	57.3
Residence	Urban	154	70
	Rural	66	30
Father's Education	Below 10th grade	58	26.4
	10th-12th grade	92	41.8
	Graduate and above	70	31.8
Mother's Education	Below 10th grade	76	34.5
	10th-12th grade	94	42.7
	Graduate and above	50	22.7
Socioeconomic Status	Low	72	32.7
	Middle	98	44.5
	High	50	22.7
Family Type	Nuclear	152	69.1
	Joint/Extended	68	30.9

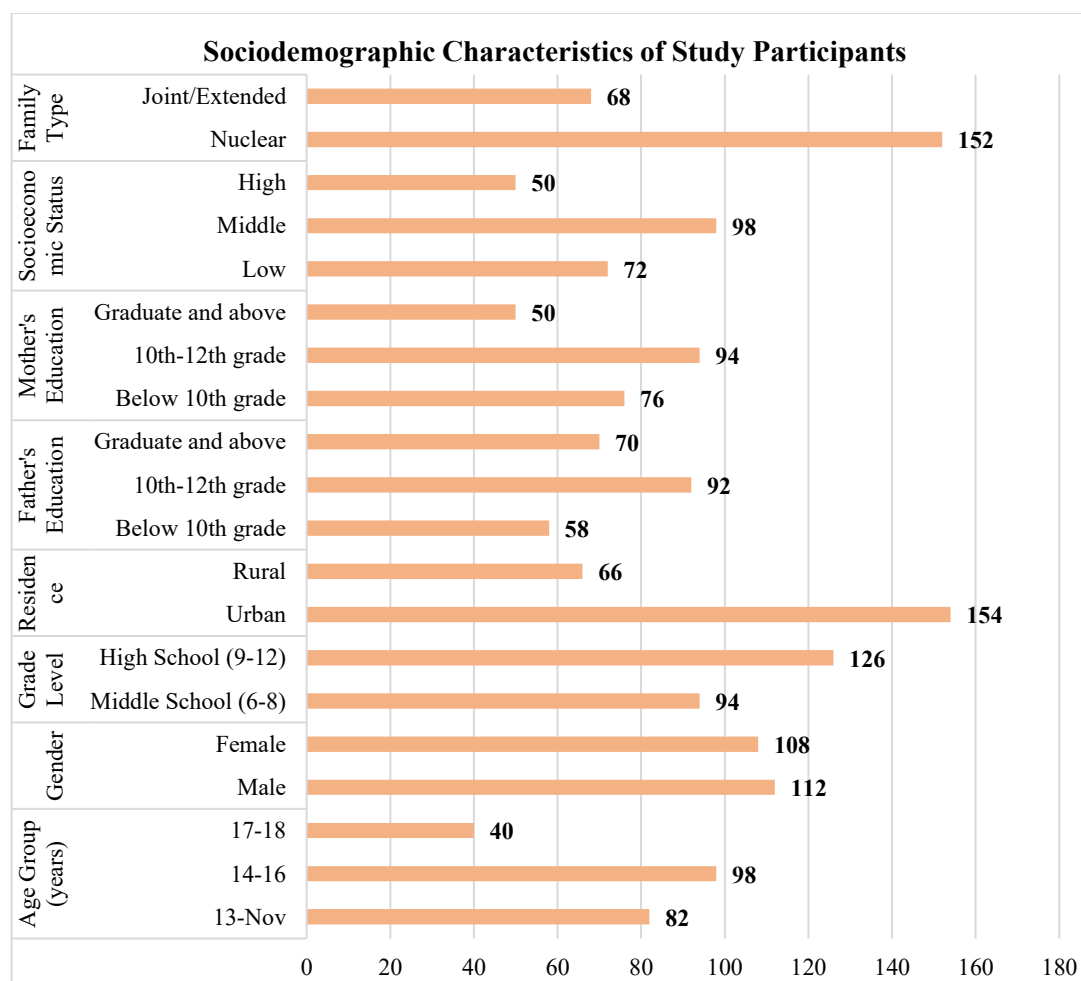


Fig: 1

Table 2: Breakfast Consumption Patterns Among Study Participants

Breakfast Habit		Overall (N=220) n (%)	Males (n=112) n (%)	Females (n=108) n (%)	p-value
Frequency of Breakfast Consumption (past week)	Never skip (7 days/week)	96 (43.6)	52 (46.4)	44 (40.7)	0.392
	Sometimes skip (3-6 days/week)	78 (35.5)	38 (33.9)	40 (37.0)	0.631
	Frequently skip (0-2 days/week)	46 (20.9)	22 (19.6)	24 (22.2)	0.64
Primary Reasons for Skipping (n=124)	Lack of time in morning	48 (38.7)	22 (36.7)	26 (40.6)	0.642
	Not feeling hungry	36 (29.0)	18 (30.0)	18 (28.1)	0.815
	Want to sleep longer	26 (21.0)	14 (23.3)	12 (18.8)	0.535
	Food not available	10 (8.1)	4 (6.7)	6 (9.4)	0.574
	Weight concerns	4 (3.2)	2 (3.3)	2 (3.1)	0.954
Breakfast Location (n=174)	Home	146 (83.9)	74 (82.2)	72 (85.7)	0.532
	School canteen	18 (10.3)	11 (12.2)	7 (8.3)	0.418
	On the way to school	10 (5.7)	5 (5.6)	5 (6.0)	0.909
Sleep Duration (hours/night)	<7 hours	82 (37.3)	38 (33.9)	44 (40.7)	0.309
	≥7 hours	138 (62.7)	74 (66.1)	64 (59.3)	

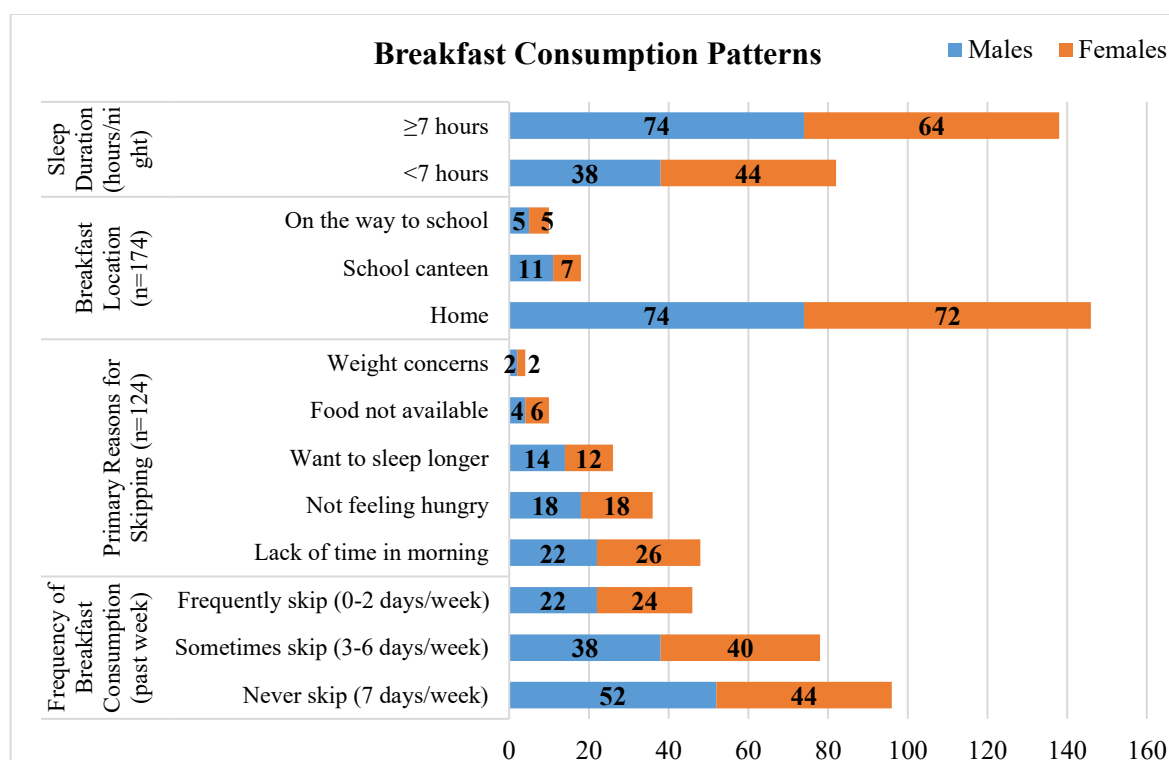


Fig: 2

Table 3: Concentration Test Performance by Breakfast Consumption Status

Concentration Measure	Regular Breakfast Consumers (n=96) Mean $\pm$ SD	Sometimes Skip (n=78) Mean $\pm$ SD	Frequent Skippers (n=46) Mean $\pm$ SD	p-value	F-statistic
Digit Span Test					
Forward span score	7.8 $\pm$ 1.4	7.2 $\pm$ 1.6	6.4 $\pm$ 1.8	<0.001	15.32
Backward span score	6.2 $\pm$ 1.3	5.6 $\pm$ 1.5	4.9 $\pm$ 1.6	<0.001	12.84
Stroop Test					
Color naming time (sec)	42.6 $\pm$ 8.2	46.8 $\pm$ 9.4	52.4 $\pm$ 10.6	<0.001	18.47
Word reading time (sec)	38.4 $\pm$ 7.6	42.2 $\pm$ 8.8	48.6 $\pm$ 9.2	<0.001	22.15
Interference score	18.2 $\pm$ 5.4	22.6 $\pm$ 6.8	28.4 $\pm$ 7.2	<0.001	35.68
Trail Making Test					
Part A time (sec)	34.8 $\pm$ 8.4	39.4 $\pm$ 9.6	46.2 $\pm$ 11.2	<0.001	20.94
Part B time (sec)	72.6 $\pm$ 15.4	82.8 $\pm$ 18.2	96.4 $\pm$ 20.6	<0.001	26.38
Teacher-Rated Attention					
Attention score (0-10)	7.8 $\pm$ 1.6	6.4 $\pm$ 1.8	5.2 $\pm$ 2.0	<0.001	33.42
On-task behavior (0-10)	7.6 $\pm$ 1.4	6.2 $\pm$ 1.6	5.0 $\pm$ 1.8	<0.001	38.26

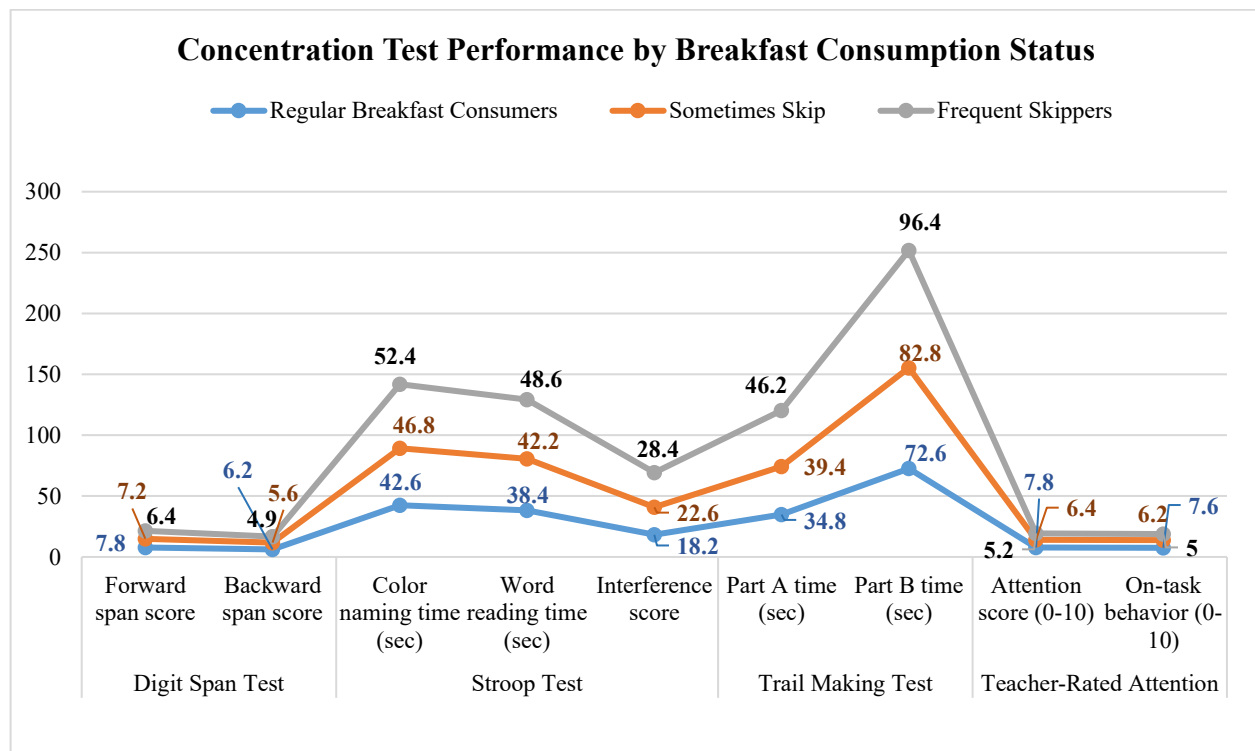


Fig: 3

Table 4: Academic Performance Indicators by Breakfast Consumption Habits

Academic Indicator	Regular Consumers (n=96)	Sometimes Skip (n=78)	Frequent Skippers (n=46)	p-value
Overall GPA				
Mean $\pm$ SD	76.4 $\pm$ 8.6	71.8 $\pm$ 9.2	66.2 $\pm$ 10.4	<0.001
Subject-Specific Grades (Mean $\pm$ SD)				
Mathematics	74.8 $\pm$ 9.2	69.4 $\pm$ 10.6	63.6 $\pm$ 11.8	<0.001
Science	76.2 $\pm$ 8.8	71.6 $\pm$ 9.8	65.8 $\pm$ 11.2	<0.001
Language	78.6 $\pm$ 8.4	73.8 $\pm$ 9.4	68.4 $\pm$ 10.6	<0.001
Social Studies	75.4 $\pm$ 8.6	70.2 $\pm$ 9.6	64.8 $\pm$ 10.8	<0.001
Academic Performance Category n (%)				
Excellent ($\geq 80\%$)	38 (39.6)	18 (23.1)	4 (8.7)	<0.001

Good (70-79%)	42 (43.8)	32 (41.0)	16 (34.8)	
Average (60-69%)	14 (14.6)	22 (28.2)	18 (39.1)	
Below Average (<60%)	2 (2.1)	6 (7.7)	8 (17.4)	
Teacher-Rated Academic Performance (0-10)				
Overall achievement	7.6 ± 1.6	6.4 ± 1.8	5.4 ± 2.0	<0.001
Homework completion	7.8 ± 1.4	6.6 ± 1.6	5.6 ± 1.8	<0.001
Class participation	7.4 ± 1.6	6.2 ± 1.8	5.2 ± 2.0	<0.001

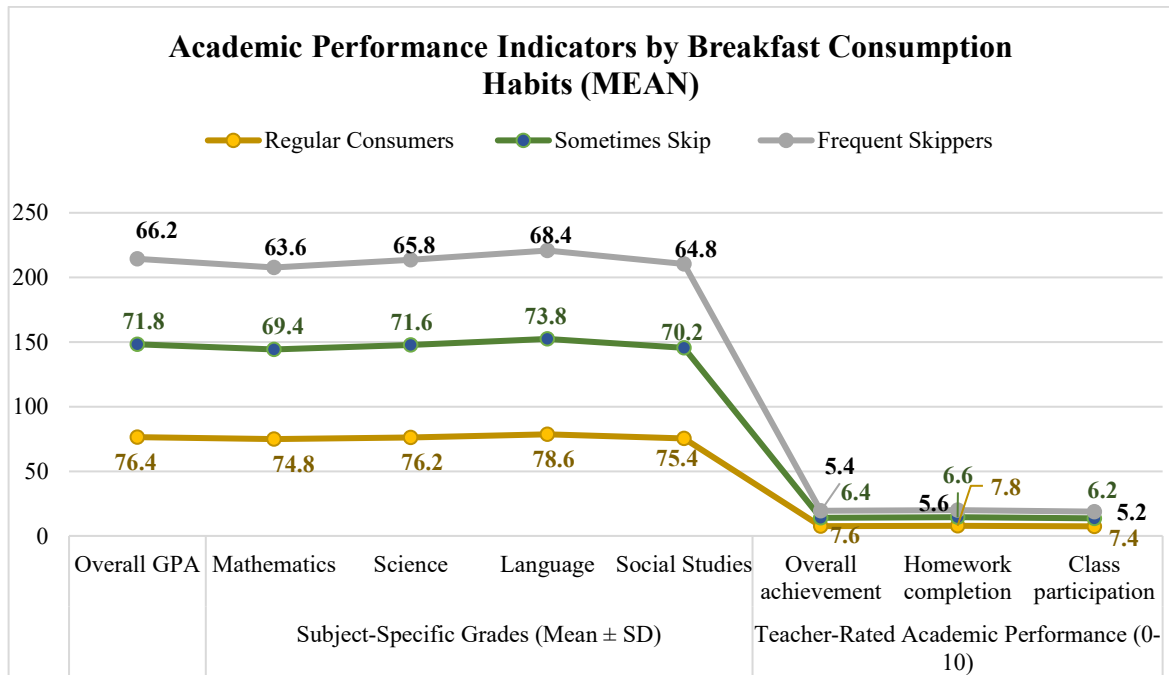


Fig: 4(i)

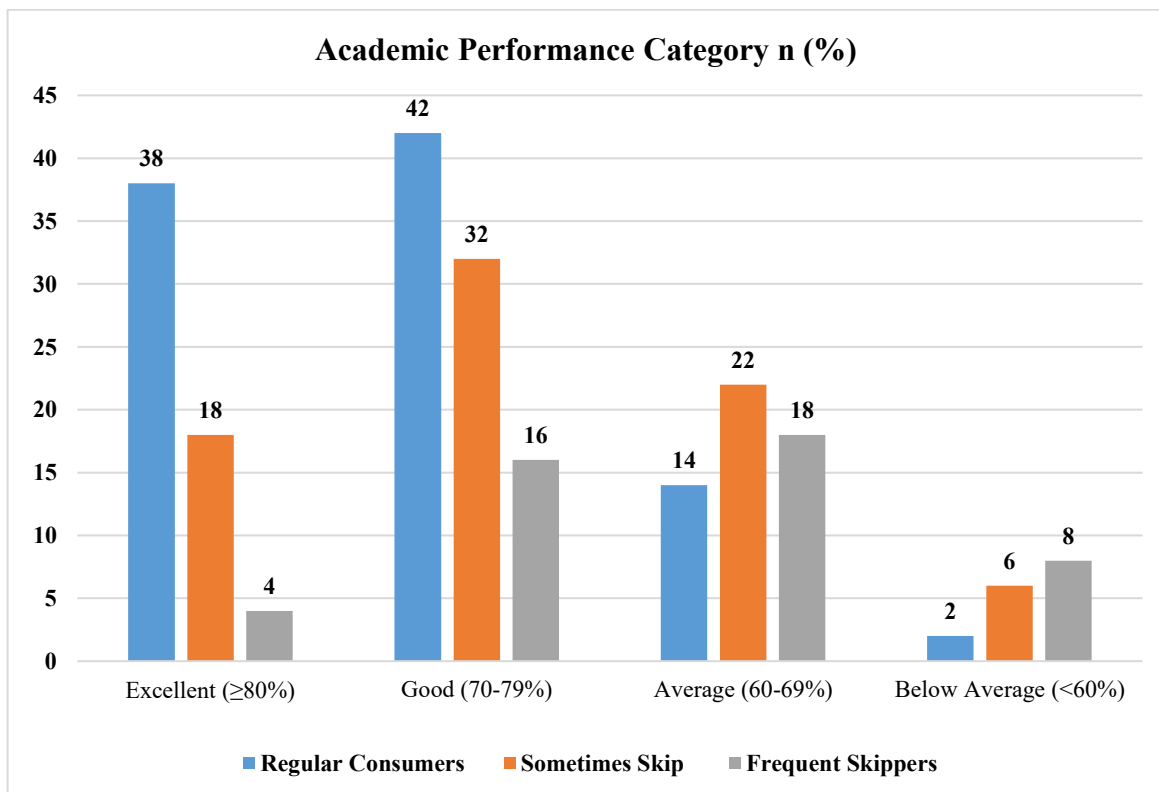


Fig: 4(ii)

Table 5: Multivariate Linear Regression Analysis: Predictors of Academic Performance

Variable	Unstandardized Beta	Standard Error	Standardized Beta	t-value	p-value	95% CI
Breakfast Frequency						
Regular vs. Frequent skip	8.64	1.82	0.326	4.75	<0.001	(5.05, 12.23)
Sometimes vs. Frequent skip	4.28	1.68	0.184	2.55	0.012	(0.97, 7.59)
Concentration Score (composite)	0.52	0.08	0.412	6.50	<0.001	(0.36, 0.68)
Age	-0.84	0.46	-0.098	-1.83	0.069	(-1.75, 0.07)
Gender (Female vs. Male)	-1.24	1.12	-0.056	-1.11	0.269	(-3.45, 0.97)
Socioeconomic Status						
High vs. Low	4.86	1.58	0.196	3.08	0.002	(1.75, 7.97)
Middle vs. Low	2.42	1.36	0.112	1.78	0.077	(-0.26, 5.10)
Parental Education (Higher vs. Lower)	3.14	1.24	0.148	2.53	0.012	(0.70, 5.58)
Sleep Duration (≥ 7 hrs vs. < 7 hrs)	2.68	1.18	0.122	2.27	0.024	(0.36, 5.00)
Urban Residence (vs. Rural)	1.86	1.28	0.076	1.45	0.148	(-0.66, 4.38)
Model Statistics						
R ² = 0.524, Adjusted R ² = 0.502, F(9, 210) = 25.68, p < 0.001						

Discussion

The present study documented that 56.4% of students engaged in some degree of breakfast skipping, with 20.9% classified as frequent skippers who consumed breakfast on two or fewer days per week. This prevalence is consistent with the substantial body of evidence demonstrating widespread breakfast omission among adolescent populations globally. Our findings align closely with research from Ethiopia reporting breakfast skipping rates of 38.1% among primary school children (Abebe et al., 2022), though our rate was somewhat higher, likely reflecting the older age of our sample given the well-documented increase in breakfast skipping with advancing adolescent age. The prevalence observed in our study falls within the range of 20-30% reported in systematic reviews of developed countries (Adolphus et al., 2013), though at the higher end of this spectrum, suggesting that breakfast skipping represents a significant public health concern requiring urgent attention in the Indian context.

Gender differences in breakfast skipping were not statistically significant in our sample, with 19.6% of males and 22.2% of females classified as frequent skippers. This finding contrasts with some previous research documenting higher skipping rates among females, potentially driven by body weight concerns and dieting behaviors. However, our observation is consistent with research from Australia demonstrating similar breakfast skipping rates across genders among school-aged children (Moller et al., 2022). The primary reasons cited for breakfast skipping in our study included lack of time in morning (38.7%), not feeling hungry (29.0%), and desire to sleep longer (21.0%), which mirror the findings from international literature examining barriers to breakfast consumption among adolescents (Godin et al., 2018). These modifiable behavioral and environmental factors provide potential targets for intervention strategies aimed at increasing breakfast participation.

Our study revealed significant dose-response relationships between breakfast consumption frequency and multiple domains of cognitive function assessed through standardized neuropsychological tests. Students who regularly consumed breakfast demonstrated superior performance across all concentration measures compared to those who frequently skipped breakfast, with intermediate performance observed among occasional skippers. On the Digit Span Test, regular breakfast consumers achieved forward span scores of 7.8 compared to 6.4 among frequent skippers, representing a substantial difference in working memory capacity. Similarly, the Stroop Test interference scores, reflecting executive function and selective attention, were significantly better among regular consumers (18.2) compared to frequent skippers (28.4), with lower scores indicating superior performance.

These findings corroborate extensive previous research documenting breakfast-related cognitive benefits. A comprehensive systematic review by Hoyland et al. (2009) examining 45 studies concluded that breakfast consumption relative to fasting exerts short-term positive domain-specific effects on cognition, particularly for memory and attention. Research from India specifically examining middle school children found that regular breakfast consumers performed significantly better on attention-concentration and immediate memory tasks compared to breakfast skippers (Gajre et al., 2008), directly supporting our observations. The Trail Making Test results from our study, showing completion times of 34.8 seconds for Part A among regular consumers compared to 46.2 seconds among frequent skippers, demonstrate meaningful differences in processing speed and task-switching ability that translate into practical advantages in academic settings requiring sustained attention and mental flexibility.

The mechanisms underlying these cognitive benefits are well-established in the neurophysiological literature. Breakfast consumption replenishes hepatic glycogen stores depleted during overnight fast, maintaining stable blood glucose concentrations that provide the brain's primary energy substrate. The adolescent brain demonstrates particularly high metabolic demands, with cerebral glucose utilization rates substantially elevated compared to adults, making adequate glucose availability essential for optimal neural function (Adolphus et al., 2013). Furthermore, breakfast consumption supports neurotransmitter synthesis, particularly acetylcholine, which plays critical roles in attention and memory consolidation processes. Our teacher-reported attention ratings, showing scores of 7.8 among regular consumers versus 5.2 among frequent skippers, provide ecologically valid confirmation that laboratory-measured cognitive improvements translate into observable classroom behaviors.

The academic performance data from our study demonstrated robust associations between breakfast consumption frequency and multiple indicators of scholastic achievement. Regular breakfast consumers achieved mean overall GPA of 76.4% compared to 71.8% among occasional skippers and 66.2% among frequent skippers, representing a 10.2 percentage point difference between regular consumers and frequent skippers. Subject-specific analyses revealed consistent patterns across all core academic areas, with particularly pronounced differences in mathematics (11.2 percentage point difference) and science (10.4 percentage point difference) between extreme groups. These findings are consistent with systematic review evidence indicating that breakfast consumption is most strongly associated with mathematics and arithmetic performance (Adolphus et al., 2019).

Our results align remarkably well with previous research from diverse geographical contexts. The landmark Indian study by Gajre et al. (2008) involving 379 middle school children found that regular breakfast consumers performed significantly better in mathematics, English, and overall academic scores. Similarly, large-scale Chinese research encompassing over 147,000 students confirmed that more frequent breakfast consumption correlated with improved comprehensive academic performance (Chen et al., 2020). Research from Ethiopia documented that breakfast skipping was independently associated with lower academic achievement scores even after controlling for confounding variables (Feye et al., 2023). A British study examining GCSE attainment found that adolescents who rarely consumed breakfast were significantly less likely to achieve higher grades, with particularly pronounced effects among low-to-middle socioeconomic status students (Adolphus et al., 2019).

The pathways through which breakfast influences academic performance likely extend beyond direct cognitive effects to encompass behavioral and motivational mechanisms. Students consuming breakfast arrive at school feeling energized and ready to engage with learning activities rather than distracted by hunger. Our teacher ratings showed that regular breakfast consumers demonstrated superior homework completion, class participation, and overall achievement compared to breakfast skippers, suggesting enhanced academic engagement. Recent research has demonstrated that achievement motivation partially mediates the relationship between breakfast consumption and academic achievement, with breakfast alleviating hunger and improving concentration, thereby increasing students' motivation to learn (Chang et al., 2021). The categorization of students into academic performance levels revealed particularly striking patterns, with 39.6% of regular consumers achieving excellent grades ($\geq 80\%$) compared to only 8.7% of frequent skippers, while 17.4% of frequent skippers fell into the below-average category compared to just 2.1% of regular consumers.

The multivariate regression analysis provided crucial evidence that breakfast consumption exerts independent effects on academic performance even after controlling for multiple potential confounders. Regular breakfast consumption compared to frequent skipping was associated with 8.64 percentage point higher GPA ($\beta = 0.326$, $p < 0.001$), while occasional consumption predicted 4.28 percentage point advantage ($\beta = 0.184$, $p = 0.012$), demonstrating dose-response relationships. Notably, the composite concentration score emerged as a strong independent predictor ($\beta = 0.412$, $p < 0.001$), suggesting that cognitive function serves as an important mediating pathway through which breakfast influences academic outcomes. The overall model explained 52.4% of variance in academic performance, indicating substantial predictive utility.

These findings extend previous cross-sectional research by simultaneously examining multiple pathways and controlling for key confounders. The independent effects of breakfast consumption persisted even after accounting for socioeconomic status, parental education, sleep duration, and residence type, all of which demonstrated associations with academic performance in bivariate analyses. Higher socioeconomic status predicted 4.86 percentage point advantage in GPA, while higher parental education was associated with 3.14 percentage point benefit, consistent with extensive literature documenting socioeconomic gradients in academic achievement. Adequate sleep duration (≥ 7 hours nightly) independently predicted 2.68 percentage point higher GPA, aligning with research demonstrating that sleep quality and duration influence both cognitive function and academic performance.

The substantial prevalence of breakfast skipping coupled with documented impacts on concentration and academic performance identified in this study underscore urgent needs for comprehensive interventions targeting this modifiable behavior. School-based breakfast programs represent one promising approach, with systematic review evidence indicating positive associations between school breakfast provision and academic outcomes, particularly mathematics performance (Adolphus et al., 2013). However, challenges including low participation rates and failure to reduce prevalence of breakfast skipping have been documented in some settings, highlighting the need for careful program design incorporating convenient timing, appealing food options, and elimination of stigma associated with program participation.

Nutritional education interventions targeting students, parents, and educators regarding the importance of breakfast for cognitive function and academic success represent another essential component of comprehensive approaches. Given that lack of time was the most commonly cited reason for breakfast skipping in our sample, interventions addressing time management, preparation of quick nutritious breakfast options, and family routines around morning meals may prove beneficial. The identification of sleep duration as an independent predictor of academic performance suggests that integrated approaches addressing multiple lifestyle behaviors including sleep hygiene, breakfast consumption, and overall healthy habits may yield synergistic benefits. Future research employing longitudinal designs to examine causal relationships and randomized controlled trials evaluating intervention effectiveness in Indian educational settings would provide crucial evidence to inform policy and practice.

Conclusion

This school-based cross-sectional study conducted among 220 middle and high school students at JIET Medical College and Hospital revealed that more than half of students engaged in breakfast skipping behavior, with over one-fifth classified as frequent skippers. The study documented significant associations between breakfast consumption frequency and both concentration performance and academic achievement, with dose-response relationships evident across multiple cognitive domains and scholastic indicators. Regular breakfast consumers demonstrated superior performance on neuropsychological tests assessing working memory, selective attention, processing speed, and executive function compared to breakfast skippers. Academic performance showed parallel patterns, with regular consumers achieving substantially higher grades across all core subjects and overall GPA. Multivariate analyses confirmed that breakfast consumption exerted independent effects on academic performance even after controlling for socioeconomic status, parental education, sleep duration, and other confounding variables. The findings provide compelling evidence that breakfast skipping represents a significant modifiable risk factor for suboptimal cognitive function and academic underachievement among adolescents, necessitating urgent implementation of comprehensive intervention strategies at individual, family, school, and policy levels to address this critical public health concern.

Recommendations

Schools should implement accessible breakfast programs with flexible timing options including before-school and in-classroom breakfast service models to overcome time barriers. Comprehensive nutritional education campaigns targeting students, parents, and teachers should emphasize breakfast importance for cognitive function and academic success while providing practical guidance on quick, nutritious breakfast preparation. Health screening programs should routinely assess breakfast consumption patterns and provide individualized counseling for frequent skippers. Family-based interventions addressing household routines, parental modeling, and home food environment modifications warrant implementation given documented familial influences on breakfast behaviors. Further longitudinal research examining causal pathways and randomized controlled trials evaluating intervention effectiveness in Indian educational contexts would provide essential evidence for optimal program design and policy formulation.

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