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# Effect of breakfast on cognitive performance of Indian school student

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**Abstract**
It has been suggested that breakfast influence cognitive performance of children. There is growing evidence that effect of breakfast is more pronounced on undernourished children. In this study, short term effects of breakfast on cognitive ability were examined in undernourished and well-nourished student. 26 undernourished and 18 well-nourished children were selected from four different primary school of semi urban area of Allahabad district. Children were randomly assigned to the control and treatment group and then four cognitive tests were performed. Statistical analysis of test scores were done by student t test and two way ANOVA at 5% level of significance ($p \leq 0.05$). The present study found after breakfast cognitive performance increases both in undernourished and well-nourished student however, significant effect were found only in undernourished children. Result of statistical analysis shows effect of breakfast is significant in undernourished student only in cognitive test of verbal fluency and arithmetic test. There were no significant main effects of nutritional group in any of the repeated measures of ANOVA. There were no other significant treatment main effects or treatment group interactions. The study suggests that omitting breakfast interferes with cognitive performance of students, an effect that is more pronounced in undernourished children.

**Keywords:** cognitive performance, undernourished, well nourished

## 1. Introduction
Cognitive development is a term that covers human perception, thinking, and learning. Nutrition is one of the important factor affecting optimum brain development and its function. Brain is most active metabolic organ whose function is depending on the continuous supply of glucose and some other nutrients. Breakfast (BF) have been consider as important meal of the day whose nutritional contribution would not be meet by any other meal of the day (Adolphus *et al.*, 2013) [1]. Despite its nutritional importance many of children comes school without breakfast (Deshmukh-Taskar *et al.,* 2010; Corder *et al.,* 2011) [7, 5]. Many studies have supported the positive association of children cognitive performance and breakfast consumption (Wesnes *et al.,* 2012) [27], it provide essential fuel after overnight fasting. Skiping breakfast has detrimental effect on cognitive test like problem solving (Pollitt *et al.,* 1983) [21], short-term memory (Corder, *et al.* 2011) [5], attention and logical reasoning (Marquez *et al.,* 2001) [17]. Effect of breakfast on cognitive performance is more pronounced in undernourished children in comparison to well nourish (Korol & Gold, 1998) [13]. This may be because undernourished children have insufficient supply of nutrients for structural functional development of brain. Previous studies have supported the relation of poor nutritional status and poor cognitive development (Pollitt and Mathews, 1998; Pollitt *et al.,* 1998) [22]. It were found malnutrition affect the myelinisation, synaptogenesis, hippocampal formation and neurotransmission in rats **(**Debassio *et al.,* 1996; Mathangi and Namasivayam, 2001). However, there are limited studies in human which describe the effect of malnutrition on brain and cognitive ability of human.
Hoyland, 2009 [11] suggested the high carbohydrate and low-glycemic breakfast provides a continuous supply of glucose, is known to facilitate better cognitive performance (Ingwersen *et al.,* 2007; Micha *et al.,* 2011) [12, 19]. Dalia is broken wheat which is high in fiber, carbohydrate and have low glycemic index, provide continuous supply of glucose for longer period of time. (Samuel, 2005) [6, 26], which in turn may influence cognitive performance. The present study has carried out to know the effect of breakfast on cognitive performance of normal and undernourished student.

## 2. Methodology

Total 100 children of 8-11yrs old children were selected from four different primary school of semi urban area of Allahabad district. Out of 100, only parents of 64children were ready to participate for the study. All were belonging to low social economic standard (SES). 17 students were excluded from the study because they were not followed the procedure of experiment properly and 8 were absent during the study. The final sample size group was 44. Undernourished student were identified on the basis of their nutritional status. Out of 44, 26 undernourished and 18 nourished students were selected in study.

**Table 1:** Characteristic of participants

| Variables | Undernourished | Normal |
|---|---|---|
| Age(yr) | 10.2+1.2 | 9.8±0.7 |
| Weight(kg) | 28.33±0.9 | 32.15±1.3 |
| Height(cms) | 134.37±11.06 | 137.79±9.1 |
| MUAC | 18.8±3.2 | 21.56±5.1 |

Values are Means ±SD.

### 2.1. Study design

Protocol and procedure regarding this experiment were explained to their parents in advance. Parents were also instructed to feed nothing at home and to give dinner till 10:00p.m. On test days, children arrived at school at the regularly scheduled time. Once attendance was taken, children were escorted to the cafeteria for the test breakfast. The standardized breakfast (Dairy + whole cereal-dahlia + 1Fruits) were provided by their parents in their Tiffin, which is taken by them at 8.00-8.30 a.m. in school. Cognitive test were conducted at 10.15-10.30. a.m.

Participants in the no breakfast condition received breakfast immediately after testing. Children were familiarized with testing procedure prior to testing day. During familiarization, the protocol of the study was explained to participants. Before taking the standardized breakfast each child was tested individually in a separate room by investigator and they were unaware of the child's treatment and nutritional status.

### 2.2. Nutritional status

Three anthropometric parameters of the subjects were taken under standardized condition. The height was measured to the nearest 0.5 cm without shoes using standiometer and weight was recorded using a mechanical beam balance, and was recorded to the nearest 0.1 Kg. Mid upper arm circumference (MUAC) was recorded with the help of flexible non-stretchable steel measuring tape to the nearest 0.1 cm, using standard technique (Lee and Nieman 2003) [15]. The height and weight measurements were compared with ICMR standard and MUAC with WHO standard, two separate standards were used as ICMR reference standards for MUAC were not available for the subjects concerned. For assessing the nutritional status of subjects, weight deficit for age, height deficit for age and MUAC deficit for age have been calculated.

### 2.3. Socio-economic status

The Socio economic status (SES) of preschoolers was determined using a Kuppuswamy's socioeconomic status scale (table 2). To assess the socioeconomic status a questionnaire was given to children's parents containing question concerned detail of parent's occupation, education family income.

**Table 2:** Kuppuswamy's socioeconomic status scale

| Education | Score |
|---|---|
| Profession or honors | 7 |
| Graduate or postgraduate | 6 |
| Intermediate or post-high school diploma | 5 |
| High school certificate | 4 |
| Middle school certificate | 3 |
| Primary school certificate | 2 |
| Illiterate | 1 |
| Occupation | |
| Profession | 10 |
| Semiprofessional | 6 |
| Clerical, shopowner, farmer | 5 |
| Skilled worker | 4 |
| Semiskilled worker | 3 |
| Unskilled worker | 2 |
| Unemployed | 1 |
| Family income per month (in Rs. as per year 1976) | |
| ≥2000 | 12 |
| 1000-1999 | 10 |
| 750-999 | 6 |
| 500-749 | 4 |
| 300-499 | 3 |
| 101-299 | 2 |
| ≤100 | 1 |
| Socioeconomic class | |
| Upper class | 26-29 |
| Upper middle class | 16-25 |
| Lower middle class | 11-15 |
| Upper lower class | 5-10 |
| Lower class | <5 |

### 2.4. Questionnaires

Screening questionnaire was filled in by the parents/carers to determine socio-economic group (Government Statistical Service, 2000) [10], and any medical history (that is, anaemia or other blood disorders, food allergies, diabetes or glucose intolerance, other acute or chronic illnesses/diseases, color blindness, severe learning disabilities and mood disorders).

### 2.5. Diet survey

A short survey determine how often children consumed breakfast before school, the quality of their normal breakfast, and their opinions on the breakfasts used in the study. The type of breakfast typically consumed and the usual breakfast eating habits were also recorded.

## 3. Cognitive test

Cognitive development refers to the way a child thinks reasons and solves the problems.

**Table 3:** Cognitive Test

| Cognitive test | Cognitive function measured | Test score range |
|---|---|---|
| Short term memory | Auditory short-term memory | 0-14 |
| Visual-Spatial memory: | Visual short memory | 0-4 |
| Verbal fluency: | retrieval of long term memory | 0-7 |
| Arithmetic test | Computational skills | 0-5 |

### 3.1. Short term memory
A digit span task was used to measure auditory short term memory of the subject. Participants were instructed to listen carefully a series of digits (e.g. 6, 8, 2) and must immediately repeat them to the instructor. After a correct repetition, they are given a longer list increased by one digit (e.g., 6, 8, 2, 4) and the test will go up to a span of 9 digits. The participants received both a forward and backward version of this task. The backward version required the child to repeat the numbers in the reverse order. For the above example, the child would repeat ''2, 8, 6.'' A score of 1 was given for each string correctly recalled. Two point if child passes both forward and backward trials, zero point if child failed both forward and backward trial. Maximum 14 point can score.

### 3.2. Visual-Spatial memory
Visual-spatial ability is a broad term that includes image generation, storage, retrieval, and transformation (Mather & Wendling, 2005) [18]. It measures the capacity of individual to visualize objects from different angles, and then remember its spatial arrangement. The odd-one-out task (adapted from Russell *et al;* 1996) [25] were used measure the capacity of individual to find out target objects set amongst distracter objects. The task consist 4x4 size display which consist four shapes(Circle, square, triangle and rectangle) in four different color(red, green, blue, orange) presented in a row. Children have to recalls the location of each odd-one-out shape, in the correct order.

### 3.3. Verbal fluency
Verbal fluency refers to an individual's capacity to generate items from long term memory. The child was asked to name as many items as possible from two sets: things to eat and animals. For each correct item 1 score was given. Maximum score would be five and minimum would be 0.

### 3.4. Arithmetic test
An Arithmetic test adapted from the Wechsler Intelligence Scales for Children-Revised was used to assess computational skill of subjects. Test began by asking the child to add and subtract simple numbers and then proceeded to more difficult items involving division, multiplication and decimals For example ask to subtract 8 from 100, record the answer, then again ask to subtract 8 from that, record the answer do this five times and give one marks for each correct answer. Maximum score would be five and minimum would 0.

## 4. Analysis
Average test scores with breakfast and without breakfast were compared by using Student's *t* test statistics. The effects of breakfast on the undernourished and well-nourished children's test scores were examined with repeated-measures ANOVA. The between-subjects factors were nutritional status (undernourished or adequately nourished) and treatment order. Analyses were performed with the SPSS (Statistical Package for the Social Sciences). Differences between means were considered statistically significant at $P \leq 0.05$.

## 5. Result
Mean score of four cognitive tests for undernourished and normal nourished children is presented in table 4&5, shows after breakfast test score increases in both undernourished and well-nourished student.

**Table 4:** Cognitive test scores in undernourished children without breakfast and after receiving breakfast

| Cognitive test | NBF | BF |
|---|---|---|
| Short term memory | 4 | 4.3 |
| Visual-Spatial memory | 1.53 | 1.92 |
| Verbal fluency: | 4.15 | 5.07 |
| Arithmetic test | 2.53 | 2.69 |

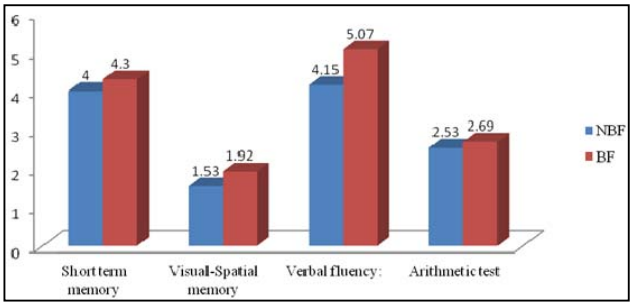


**Fig 1:** Cognitive test scores in under nourished children

**Table 5:** Cognitive test scores in well-nourished children without breakfast and after receiving breakfast

| Cognitive test | NBF | BF |
|---|---|---|
| Short term memory | 8.44 | 8.77 |
| Visual-Spatial memory | 2.55 | 2.88 |
| Verbal fluency | 4.55 | 4.69 |
| Arithmetic test | 3.5 | 4 |

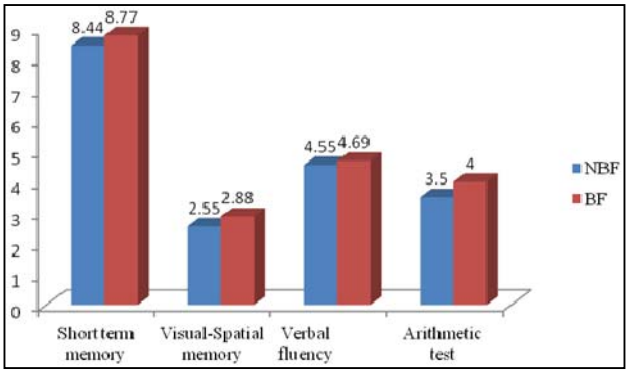


**Fig 2:** Cognitive test scores in well-nourished children

**Table 6:** t test value of cognitive test of undernourished and well-nourished children

| Cognitive Test | Undernourished | Well Nourished |
|---|---|---|
| Short term Memory | 0.48 | 0.66 |
| Visospatial Memory | 0.12 | 0.128 |
| Verbal Fluency | 0.048* | 0.138 |
| Arithrimatic Memory | 0* | 0.207 |

Superscript "a" significantly different from well-nourished group: $P \leq 0.05$ (Student's t test).

### 5.1. Short term memory
Mean score of digit recall revealed short term memory of children is presented in Table 4 Result shows after breakfast mean score of digit recall increases in both undernourished and normal nourished students however; it is insignificant ($p \leq 0.05$). Analysis of ANOVA shows there were also insignificant effect of interaction BF*NS [F (1, 40) =0.18, p=0.67] on the short term memory of children.

### 5.2. Visuospatial memory
Result of t test shows there was an insignificant effect of breakfast on the visuospatial memory of undernourished and normal nourished student while mean score of visuospatial memory increases after eating breakfast in both undernourished and normal nourished students.

### 5.3. Verbal fluency
Mean score of verbal fluency shows after breakfast verbal fluency increases in both undernourished and normal nourished students. However, result of t test shows significant effect of breakfast were seen only on undernourished student whereas performances of nourished student were not increases significantly. This finding were supported the study of Anne marie *et al.,* 1994. Analysis of Anova shows there were significant effect of BF [F (1, 40) =6.5, p=0.15] and NS [F (1, 40)=3.65, p=0.631] on verbal fluency which implies relation of breakfast on verbal fluency is not depend on nutritional status.

### 5.4. Arithmetic memory
Mean score of arithmetic memory increases after eating breakfast in both undernourished and normal nourished students. Result of t test shows problem solving ability of undernourished students significantly increases after breakfast, although has insignificant effect in normal nourished children. There were significant effect of interaction of BF [F (1, 40) =40.4, $p$>0.00] and NS [F (1, 40) =2.6, $p$=0.011] on problem solving ability.

### 5.5. Diet survey
Result of diet survey of undernourished student reported 32% of the children were send without breakfast,20% were send school with feeding breakfast sometimes and only 48% were regularly eat breakfast (figure 1). Whereas diet survey of nourished children's shows 18% student comes without breakfast, 24% sometimes eat breakfast and 58% student regularly eat breakfast before arriving in school.

**Table 7:** Breakfast pattern for well-nourished and undernourished students

| Breakfast consumption | Undernourished | Well nourished |
|---|---|---|
| Without breakfast | 32% | 18% |
| Feeding sometimes | 20% | 24% |
| Regular breakfast | 48% | 58% |

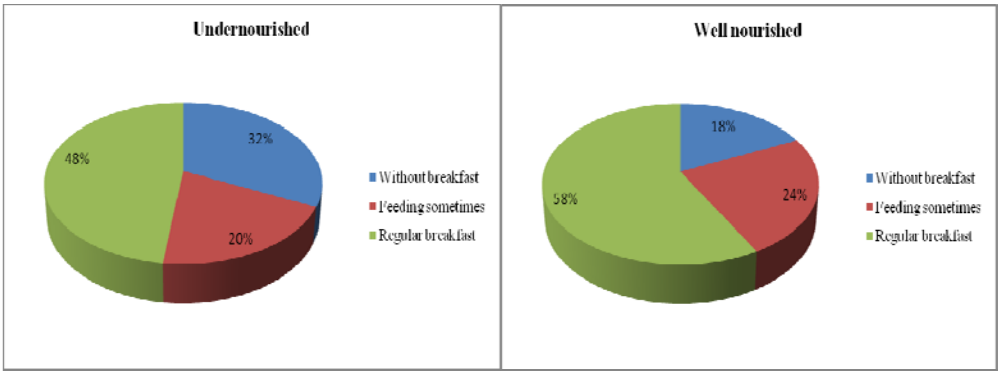


**Fig 3:** Graphical representation for breakfast consumption

## 6. Discussion
This research examined the effects of standardized breakfast vs no breakfast on cognitive performance of undernourished vs. adequately nourished children. Researches on cognitive performance of children suggested that consumption of breakfast have better effect on cognitive performance of children (Rampersaud, 2009) [24]. However, effects of BF on cognitive performance were inconsistent in different study. (Benton *et al.,* 1987; Dwyer *et al.,* 1972; Lieberman *et al.,* 1976) [8, 16].

Mean score of cognitive test increases after consuming breakfast in both undernourished and nourished student (Table 4, 5). The most possible hypothesis is that overnight fasting decreases blood glucose level and supply of glucose and nutrients to brain. These could thus interfere with certain brain functions. In a randomized controlled trial, when under nourished children missed breakfast, their performance on tests of verbal fluency, auditory short-term memory and perceptual speed was detrimentally affected, whereas performance of adequately nourished children was not (Simon and Grantham-McGregor 1989) [23]. The most possible hypothesis is: Undernourished children are more susceptible to infection and frequently ill, therefore feel lethargy, irritable, non-attentive. This may limit their interaction and explorer to environment. This could also lead their caregivers to treat this child negatively than healthy attentive child. Inadequate availability of nutrients affects the structural functional development of brain.

Result of t test shows effect of breakfast is significant in undernourished student only in two cognitive test verbal fluency and arithmetic test (table 6). Breakfast omission was associated with a decline in performance on a verbal fluency test and tasks of arithmetic scores. Effect of breakfast on verbal fluency is supported by the study of Simon and Grantham-McGregor 1989 [23]. From the result we can see that there is significant effect of breakfast on arithmetic score of the students the result is same as in the findings of Powell *et al,* 1983 and of Adolphus *et al.,* 2013 [1].

There were no significant main effects of nutritional group in any of the repeated measures of ANOVA. There were no other significant treatment main effects or treatment group interactions. This result is supported by other studies suggested positive effect of breakfast is more remarkable in undernourished children than well nourished (Hoyland *et al.*, 2009; Pollitt *et al.,* 1998) [11, 22].

## 7. Conclusion
In developing countries undernourished children are always more disadvantaged than adequately nourished children in several socio cultural factors. It is important to know breakfast could improve cognitive ability of undernourished. The present study found a significant effect of breakfast on

cognitive performance of undernourished student while in normal nourish student after breakfast cognitive performance increases but it is not significant ($p \leq 0.05$).

The result of study suggests that omitting breakfast interferes with cognitive performance of students, an effect that is more pronounced in undernourished children.

The practical implication of these findings is important as long period of omission of breakfast may impair their capacity to work in school and consequently their school achievement will be adversely affected.

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