

# Impact of Nootropic Supplementation on Adolescents Selective Attention and Working Memory

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**Abstract:** Nootropics are group of heterogenous compounds which are found naturally in food or in its synthetic forms which when consumed can improve mild cognitive decline induced by ageing or by certain medications. They are termed as brain foods or cognitive enhancers. The study aims to analyse whether consumption of Nootropic foods in the present study Brahmi can improve certain cognitive functions such as selective attention and working memory in comparison with a control group who was given no nootropic foods. A cross-sectional multi-center study involving 300 healthy individuals ranging from age 13-15 years from three different residential schools were randomly selected. A subset of 40 participants were finalized with their parent's consent and participants assent before intervention. The intervention period was 60 days and muffin was given as a part of their snacks. After 60 days computer based psychological testing was carried out. Data was analyzed and finding show improvement in working Memory (DST) and selective attention task (Stroop test). The difference was statistically significant with a  $p$  value  $< 0.05$  at 95% confidence interval. There was no effect on short term memory (Forward span) and error scores in Stroop test. Furthermore, a large cohort, longitudinal study involving biophysical tests like MEG can further strengthen the findings.

**Keywords:** Nootropics, Stroop test, Digit span test, Brahmi, adolescents, cognition

## 1. Introduction

The term "adolescence" is a latin verb "adolescere" which express the notion of "growing to maturity". During adolescence, white matter in the brain continues to grow and becomes thicker, likely due to increase in myelination- a process that helps brain signals travel faster. This growth supports better co-ordination, thinking and information processing. Specific regions of grey matter which are involved in decision making and processing information also increase. The frontal lobe used for planning and thinking, temporal lobe linked to memory and understanding language keeps growing Thus, these changes in the brain are closely linked to development of advanced cognitive abilities.

The term cognition is a latin word meaning 'get to know' which determines the daily activities of an individual. It is responsible for the way an individual receives information, manipulate, respond, behave and store information. The cognitive abilities decline as a part of natural process because brain cells die and are not replaced effectively. The assessment of such functions is imperative to be able to improve the overall growth and achievements. This assessment is also important to detect mild cognitive decline, age related mental decline and trauma related mental decline which in turns helps to identify the cause of decline in a particular cognitive function and understand its repercussions and also direct the treatment. Many major health issues worldwide are linked to cognitive difficulties and thus identifying them at an early can prevent from neuropsychological conditions like alzheimer's diseases, schizophrenia, depression, ADHD, Autism and most common dementia. Assessment during adolescences, improve certain lifestyle changes which helps to slow down normal age-related mental decline if any.

Nootropics are group of foods and synthetic compounds known to improve brain function especially cognition. They are found naturally in foods (walnuts, blueberries, turmeric, flax seeds etc) and herbs like Brahmi (bacopa Monneri), Ginkgo, ashwagandha and synthetic formulations. These foods helps in learning and improving memory whether natural or induced cognitive impairment. Nootropics improve oxygen supply, protect from free radical damage and prevent neurotoxicity.

The present study aims to explore the impact of nootropic foods on the selected cognitive skills among the adolescents aged between 13-15 years in residential schools of Hyderabad. A review of literature shows studies done on nootropic supplements in form of capsules, standardized extract, isolated formulations, liquid formulations at several dosages. A study on omega 3 fatty acids by *kim et al* showed improved memory and academic grades in 9448 school children. A study by *Navneet et al* in a randomized double blind placebo control on medical students given bacozone (brahmi supplementation) 150mg twice daily improved attention, working memory and comprehension. None of studies specifically assessed the cognitive functions using nootropic foods. Hence this study is an attempt to know the impact of these foods on selective attention and working memory in adolescents. The primary objective of the study is to determine whether participants in the trial group on nootropic foods performed better in selective attention and working memory test than control group.

## 2. Methodology

A cross- sectional multi- centre study was conducted with adolescent girls and boys of age group 13 to 15 years were selected randomly from three different residential schools of Hyderabad contributing to a sample of 300 participants.

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Screening was done for all participants. A subset of 40 subjects were selected for carrying out the interventional study. Sample size was calculated using Neyman’s optimal sub sample size for surveys. Institutional ethical clearance was obtained prior to intervention. Intervention involved conducting Computurised based test using Psytoolkit. The inbuilt test used were Digit span test (forward and reversed) for working memory and Stroop test for assessing selective attention.

**Phase 1: Screening**

All personal details like Parents qualification, social economic status, birth order of child, academic ranks, extra-curricular activities, sleep duration and use of supplements were noted down by conducting personal interviews. This helped in selection of participants and all those who did not fit the criteria were excluded from the study. Participants or caregivers who did not agree to continue, or have established cognitive or learning disabilities or were on any nootropic supplementation were also excluded from the study. The participants were then given the option to choose the muffin they like between plain muffin (PM) and Muffin containing brahmi(BM). Twenty participants under each group was formed and 2 participants from both groups could not continue with study. So the study was accomplished with 18 participants from each group making the total sample as 36.

**Phase 2: Intervention Phase:**

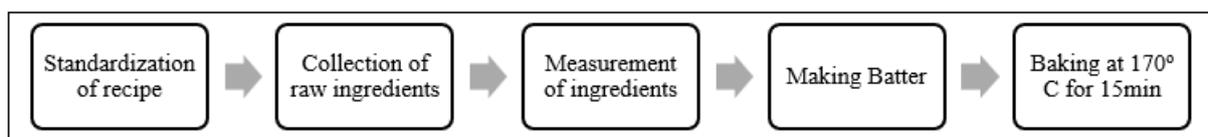
A 50g Muffin was formulated using a standardized recipe for plain muffin and brahmi muffin, whose sensory evaluation,

Nutrient analysis and shelf life studies was carried out. The brahmi used in the muffin was powdered brahmi of about 0.5g/ 50g. The Muffin was given to participant in their snack time daily for a period of 60 days.

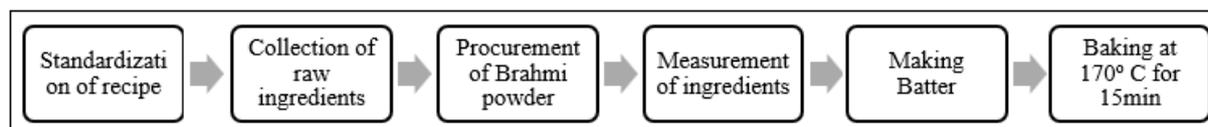
**Procedure**

All Purpose Flour, unsalted Butter, fresh Egg, Milk, White Sugar, Salt, Baking Powder, cinnamon powder was used in all preparation of muffins with variations only in functional ingredient. Kenstar microwave Dura Chef Model No: KJ20CSL3 was used. Pre-heating of Oven to 180°C was done, Teflon – Alloy steel Muffin tray was lined with paper liners and kept aside. In a small bowl all-purpose flour, sugar, baking powder and baking soda was measured and sifted, mixed together using silicone spatula. In a medium bowl, milk, melted butter were mixed and egg was whisked separately and all were combined using electric whisker (Philips HR3700/30 200watt hand whisker). All dry ingredients were added to wet ingredients and combined well with spatula to avoid any lumps and in one direction to avoid loss of air from batter mixture. The muffin was baked for about 15min and checked for doneness. Later it was cooled and measured.

The recipe for muffin was then varied in terms of its functional ingredient which included ingredients brahmi powder in different amounts such as V-I 0.5g, V-II 1g, V-III 2g respectively.



Flow diagram for preparation of Plain Muffin (PM)



Flow diagram for preparation of Brahmi Muffin (BM)

Organoleptic Evaluation: The Muffins made were subjected to sensory evaluation like taste, texture, appearance & overall acceptability using a 5- point hedonic scale ranging from 1 as dislike extremely and 5 as like extremely as mentioned in table 1. It was carried out with semi trained members. 31 Healthy Adults of age group 18-21yrs individuals evaluated the muffins. Fresh clean water was provided to rinse their mouth before & after every evaluation. Assessment was done for plain and Brahmi muffin with its variations namely BM (I, II, III) The average score was calculated for individual organoleptic properties. The product well accepted was then sent for Nutrient & phytochemical analysis.

**Evaluation of Muffin for Shelf life:**

Hundred grams muffin of brahmi and plain were packed in a sealed in a polythene bag at room temperature ranging from 20°C to 25°C and relative humidity from 50 to 60 percent. The muffins were evaluated for biological & sensory quality on six days of storage.

**Phase 3: Psychological Testing:**

Computer based testing: A personalized laptop with the registered psytoolkit account was used and the inbuilt psychological tests namely Digit span test (forward and reversed/backward) and Stroop test was carried out effectively. The data is stored in the psytoolkit account and is retrieved in the excel format. In the DST test a series of digits are flashed for the participant to memorize followed by typing the digits from the keyboard. Forward span and backward span both were recorded same way till the participant gives 2 incorrect response consecutively. The test end with maximum length of digit remembered by the participants.

**Table 1:** 5- Point Hedonic scale

Dislike extremely	Dislike lightly	Neither like or dislike	Like slightly	Like extremely
1	2	3	4	5

This was noted to interpret and know short term memory and working memory of participants.

Stroop test: Stroop Test web version was used where participants were explained the process of carrying out the exam. Stroop test assesses the selective attention of participants. The written instruction was flashed on the screen and explained orally with an example. In this test participants were asked to press the letter from the keyboard corresponding to the ink colour noticed by them. For example, the participants see the ink colour as “GREEN” but the colour name is “BLUE”, the participants is supposed to press letter “G” on keyboard likewise for an ink colour “BLUE”, the colour name showed is also “BLUE” then the participant is supposed to press letter “B”. The former is an incongruent condition while the latter is called congruent condition. The reaction time taken for both these conditions and the number of correct and incorrect responses were noted. The test was carried out for both control and Brahmi group. All the raw scores were downloaded from the psytoolkit account and a raw data excel file was made.

Statistical analysis: The raw data was subjected to SPSS version 26.0 Descriptive Test, Parametric Test and Non parametric test was done depending on the distribution of normality. An Independent sample t-test was employed to compare the means of both the groups. Confidence interval was set at 95% and statistical significance at 0.05.

### 3. Results & Discussion

The average age of the participants in control group was 13.6±0.697 years and in Brahmi Group was 14.0±0.63 years.

#### Nutritional Quality of Muffins

Nutrient Analysis for Plain Muffin was done at NCML Labs, Hyderabad for proximate principles. Table 2 shows Nutritive value of the muffin per 100g. The most accepted product was sent for phytochemical analysis namely alkaloids for bacosides for BM, The total bacoside content as bacoside A of Brahmin Muffin was 0.025% i.e., 2.5mg

**Table 2:** Nutritive Value for Muffins for 100g

Proximate Principles	Calculated Nutritive Values*	Nutritive values
Energy (K.cal)	254	369.46
Protein (g)	5.68	5.67
Carbohydrates (g)	18.7	50.83
Fats (g)	17	15.94

\*Values calculated from IFCT 2017, NIN, ICMR

**Sensory Quality & Storage Studies:** Sensory Evaluation was done for all the variations for brahmi muffin and plain muffin. Brahmi Muffin with 2g Brahmi powder was not at all accepted by the participants. Variation I with 0.5g of Brahmi powder was better accepted. With regards to brahmi muffin there was significant difference among the all the sensory attributes as shown in table 3

**Table 3:** Sensory Score Mean Values and p values

Variation	Taste	Texture	Appearance	Flavor	Overall acceptability
Control	3.64±0.55	3.61±0.49	3.45±0.56	3.77±0.42	3.61±0.49
BM I	2.25±0.85	2.83±0.77	2.96±0.87	2.64±0.55	2.45±0.80
BM II	1.43±0.67	1.96±0.66	2.13±0.89	1.8±0.76	2±0.87
BM III	1.03±0.18	1.5±0.73	1.63±0.85	1.93±0.9	1.43±0.62
p-value	0.00	0.00	0.00	0.00	0.00

Shelf- life studies was done for all three types of muffins, the sensory quality for flavour and texture was reported as sweet & spongy on 6<sup>th</sup> day of storage. Microbial count for yeasts & moulds were <10 CFU/g for all muffins.

#### Psychological testing:

DST (forward Span): This test measures short term memory working memory of the participants, the average length of digit remembered was 5.11± 1.07 for forward span (FS) and in case of brahmi group 5.22±1.12. The minimum score was 3 and maximum was 7 for control group and in brahmi group minimum score was 3 and maximum was 7 digits. The difference between the groups was not statistically significant with *t-value* -0.453 and *P* >0.05 for a two tailed t-test (table)

Backward span: This test measures working memory of the participants. The average length of digits remembered was 3.66± 0.90 for control groups and 4.55±1.14 for brahmi group. A minimum score was 2 and maximum was 6 for control group, 3 and 7 was minimum and maximum score in brahmi group. The difference between control and brahmi group was found to be significant with *t-value* of -0.25 and *p-value* <0.05 for a two tailed t-test(table)

**Table 4:** Results for digit span scores between the groups

	Control group			Brahmi group			t-value	p-value
	Mean ±SD	min	max	Mean ±SD	min	max		
Dst (FS)	5.11± 1.07	3	7	5.22±1.12	2	6	-0.453	0.653
Dst (BS)	3.66± 0.90	3	7	4.55±1.14	3	7	-0.25	0.015

Stroop test: The reaction time taken for incongruent conditions and error score was recorded. The reaction time in control group was 1086.0±202.8ms and in brahmi group was 878.4.6 ±140.6ms and the error score was 6.75± 5.90 and in brahmi group 4.16±3.86. P-value <0.05 for reaction time taken to respond to a incongruent condition which indicates significant difference between control and brahmi group at two tailed t test, however p value for error score difference was insignificant. (Table 5)

**Table 5:** Comparison of Mean scores for Rct's and Error Score

	Control group	Brahmi group	t-value	p-value
	Mean ±SD	Mean ±SD		
Rct(ms)	1086.0±202.8	878.4.6 ±140.6	3.563	0.001
Error score	6.75± 5.90	4.16±3.86	0.98	0.922

### 3.1 Discussion

In the present study, adolescent girls and boys who consumed nootropic muffins containing brahmi for a duration of 45 days showed significant improvement in their cognitive abilities for working memory and selective attention when compared to the control group which received plain muffin. Brahmi is a potent cognitive enhancer and component responsible for this effect is due to the class of saponins names bacosides A and B. A study by Devendra et al reviewed Bacopa Monnieri as a functional food ingredient in food processing industry due to its clinical and therapeutic benefits especially as nootropic. A randomized double blind placebo control by *stough et al* which was done for a duration of 90 days on supplementation with Keenmind containing 150mg of bacopa Monniera extract showed improved performance on the working memory. The study also supported two other published studies reporting cognitive enhancing effects in healthy humans.

Cognitive functions are constantly developing throughout infancy, childhood, adolescence and later adult life. The cognitive functioning declines as a part of normal aging process in every individual. Basic development occurs in the first 10 years of life followed by advanced development which includes the ability to think about possible outcomes, understand what makes a good argument consider different sides of an issue, compare ideas with evidence, think about how things work, understand other persons' point of view, make decisions based on moral principles and reflect on their own identity and beliefs. Adolescent stage is marked by remarkable structural brain development, white matter continues to grow and become thicker due to myelination as evidenced by histological and magnetic resonance imaging studies which influences the functionality of brain. Hence it's a crucial life stage where various factors can influence the cognitive development. These factors are not only effected by genetic and fetal environment but also shaped by experiences and lifestyle.

Nootropic foods thus can support this development and help in improving any mild cognitive impairments. The nootropics contain heterogenous chemical compounds and are found naturally in foods and in its synthetic forms. One such Nootropic is Bacopa monniera or Brahmi which contains active components such as alkaloids and saponins- bacosides A and B. The psychological tests used in study were to assess the working memory and selective attention tests. The findings of the study revealed improvement in participants memory to recollect the digits forward and backwards. Although there was no significant improvement in short term memory but the working memory improved in participants of brahmi group. Likewise the stroop test is measure of stroop effect which explains the selective attention and focusing on the stimulus while ignoring the distractions. The findings of this test also shows improvement in reaction time for incongruent conditions compared to the control group.

### 4. Limitations

The study has its own limitations, a large cohort longitudinal study will add on the existing evidence on the impact of nootropic foods on adolescent age group. Further studies can

be done by congriming this effect using MEG-magnetoencephalography in knowing the changes that occurred upon such intervention.

### 5. Conclusion

It may be concluded from the study that participants who incorporated brahmi as a part of their diet performed better in psychological tests compared to their counterparts. To avoid biases and influence of participants on each other the groups were selected randomly from three different schools. Thus brahmi or any nootropic foods can be incorporated in the menus of these residential school and in public or private setups to support their academic performance and over all well being.

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