Original Research Article

Food for Thought: Effect of Afternoon Meals on Executive Functioning of the Brain

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Abstract

Background: Cognition is the mental action or process of acquiring knowledge and understanding through thought, experience and the senses. Meal is one of the important factors affecting cognition level in healthy individual. The main objective of this study was to assess the change in cognition levels, if any, before and after lunch in healthy working individuals.

Materials and methods: It was a quasi-experimental before-after study carried out on 80 healthy (age group- 18-60 years of either sex) individuals working in Kalpana Chawla Medical College, Karnal, Haryana. These individuals were allowed to have their normal lunch which was presumed to be of mixed nature (moderate quantities of carbohydrates, proteins and fats). Subjects were screened for cognitive impairment through Mini mental state examination. Cognitive performance of those having normal cognition levels was assessed using Trail making test (A and B) before and after consumption of lunch. Statistical analysis of acquired data was carried out through paired t-test with significance set to 5%.

Results: Post-lunch time taken values for completing Trail A and Trail B test were found to be reduced. Statistical significance ($p < 0.01$) was reached for Trail B test.

Conclusion: The findings of this study showed that there occurs an improvement in the working memory and executive control of brain post-lunch. Thus, we can postulate that having a proper lunch in terms of size and proportion of macro-nutrients (mixed diet) and that too at a proper lunch time improves our cognition levels and may increase working efficiency at designated work places.

Key words

Attention, Cognition, Memory, Trail test.

Introduction

Cognition is the mental action or process of acquiring knowledge and understanding through thought, experience and the senses [1]. Cognition represents a complex, multidimensional set of abilities. Cognition includes processes such as human perception, attention, learning, memory, concept formation, reasoning, judgment and decision making, problem solving, and language processing [2].

Various components of cognition involve numerical, verbal, spatial and mechanical reasoning. Memory, reasoning, attention and psychomotor coordination are only a few of the functions that contribute to mental ability. Memory itself is a very complex set of processes (e.g. short-term, long-term, visual, spatial, verbal, declarative, semantic, and strategic) that can be investigated using different assessment tools [3]. Assessment of cognitive function is a challenging yet an integral component of psychological, psychiatric, and neurological evaluation [4].

Factors affecting cognition impairment that have been identified includes age, education period, gender, health life factors such as alcohol drinking and smoking, depression, social factors such as social activity and occupation, history of disease, and body mass index (BMI) and many other factors [5].

Meal is one of the important factors affecting cognition level in healthy individual. Diet and components of diet like carbohydrates and protein intake have known to substantially affect the post-prandial glucose levels. It is well established that poor nutrition, particularly early in life, can have lasting effects on brain functioning and cognitive performance. In contrast, much less is known about the short-term effects of meals on cognitive behavior in well-nourished individuals. Interest in this area of research has primarily stemmed from the desire to improve cognitive performance in either the workplace or classroom [5].

Cognition tests are form of psychometric and neuropsychological assessment designed to measure general intelligence. Typically, cognition ability tests cover following categories – numerical, verbal, spatial and mechanical reasoning. Various cognition tests are assessed to check the cognition capability of an individual. There are various simple tests to assess cognition levels such as IQ test, GPCOG/MCOG test, clock test, Trail making test, Stroop test, Stanford- Binet intelligence scale, etc. [5].

Different studies have analyzed the effect of lunch on cognition. However, there is a paucity of literature defining the exact role of afternoon meals on different aspects of cognition. Some have found meals to be a facilitator of cognitive tasks whereas others have reported a post lunch dip on certain components of cognition.

This study was designed keeping in mind the general middle-class working population in India.

The main idea was to study the post-lunch cognition levels in people working at their work places from 9 am to 5 pm and having a lunch composed of normal mixed diet which they take in routine during their official lunch hours.

Aim and objectives

- The main objective of the study was to assess the change in cognition levels, if any, before and after lunch in healthy working individuals.
- Cognitive attributes such as executive control, working memory, psychomotor speed etc. which have a direct impact on the work output of the individual were explored using Trail Making test.

Materials and methods

Study design: Quasi-experimental before-after study.

Study group: Sample size was 80 (40 males and 40 females) of age group (18-60 years), full time employees of Kalpana Chawla Medical College, Karnal (Haryana) with minimum education level Grade V (formal schooling).

Inclusion criteria

- Age 18-60 years
- Minimum education level class V (formal schooling)
- Full time employees of KCGMC Karnal
- Having proper lunch routine during lunch break i.e. 1 pm - 2 pm
- Having mixed normal diet and following their daily routine like smoking, tea, coffee, etc.
- MMSE score ≥25

Exclusion criteria

- <18 - >60 years
- Uneducated
- Do not have proper lunch
- MMSE score <25
- Any chronic illness, childhood attention disorders
- Epilepsy, hypertension
- History of head injury
- CNS pathology

Methodology

The subjects fitting in inclusion criteria were selected. Informed consent form and Participant information sheet were duly signed by them. Study protocol was duly approved by the Institutional Ethics committee (IEC).

Pre-lunch testing was done between 12:00 noon to 1:00 pm, just before the official lunch hour i.e. 1 pm – 2 pm. The subjects ate lunch which they regularly bring or eat during lunch hours. They were allowed to follow their daily routine like having tea, coffee or smoke during pre-lunch or post-lunch hours or in between. Post lunch testing was done after 1 to 1 ½ hour of their meals i.e. between 2 pm-3 pm in the afternoon.

Cognitive testing: Simple paper and pencil tests were performed on subjects with minimum education up to class V (formal schooling) and understood Basic English.

Mini-mental state examination (MMSE) was done to assess the general cognition levels of the individual. Those who scored <25 were excluded from the study while those having scores ≥25 on MMSE test were administered Trail A and Trail B test.

Time taken to complete Trail A and Trail B test was noted separately (in seconds). Performance is considered to be impaired if scores exceed 40 seconds for part A and 91 seconds for part B. The time taken to complete the test was recorded. If an error occurred, the participant was directed to correct it but the clock used to time the test was not stopped. Total time taken to complete the task was considered as the final score. Number of errors was not recorded [6].

The participants in our study knew the English alphabet and numbers; although they did not use English regularly. We considered translating numbers and letters into Hindi, but due to difficulties with matching the letters used in the TMT, this was considered not feasible [7].

Statistical analysis

Student‘s t-test (Paired) was applied to the results obtained after completion of the study. Pre-lunch and Post-lunch levels of cognition were assessed by using Mean values, Standard Deviation, t-value and p-value. Significance was tested at “5%” and expressed in terms of “P” value with $p < 0.05$ = statistically significant. SPSS software version 20.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis.

Results

The study was conducted at Department of Physiology, Kalpana Chawla Medical College,

Karnal, Haryana (India) from July 2018 to September 2018. Demographic characteristics of the study participants are shown in **Figure - 1 and 2**.

Figure - 1: Age wise distribution of study subjects.

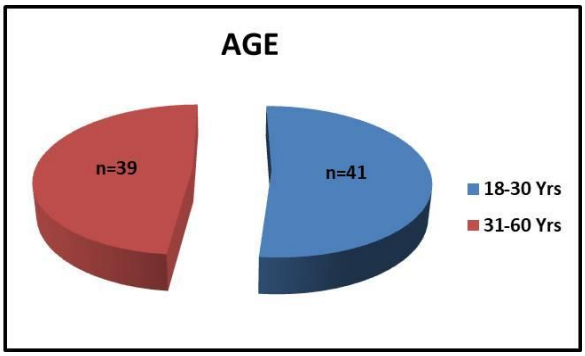


Figure - 2: Gender wise distribution of study subjects.

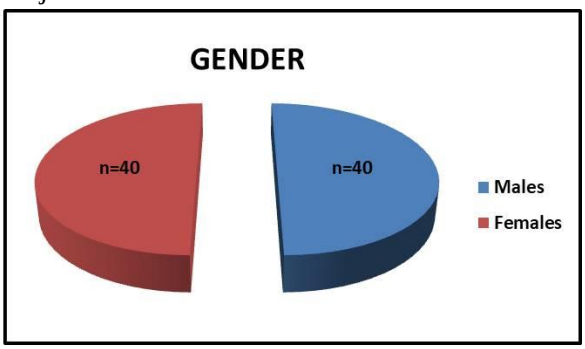
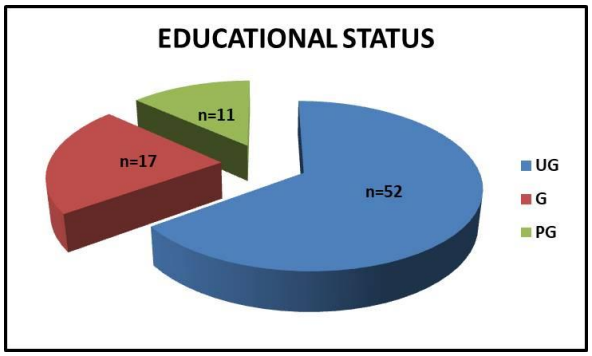


Figure - 3: Distribution of subjects as per educational level.



* UG= Under-Graduate, G= Graduate, PG= Post-Graduate

Figure - 3 shows how the study subjects were distributed as per their educational status. Maximum number of study participants was undergraduates.

Figure - 4: Distribution of subjects based on their MMSE Score.

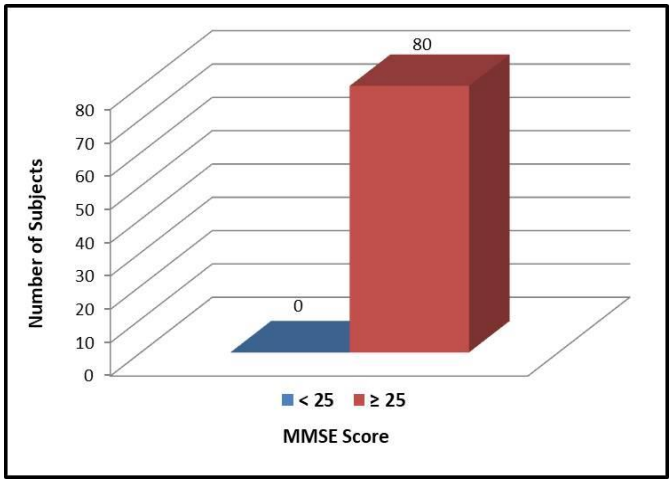
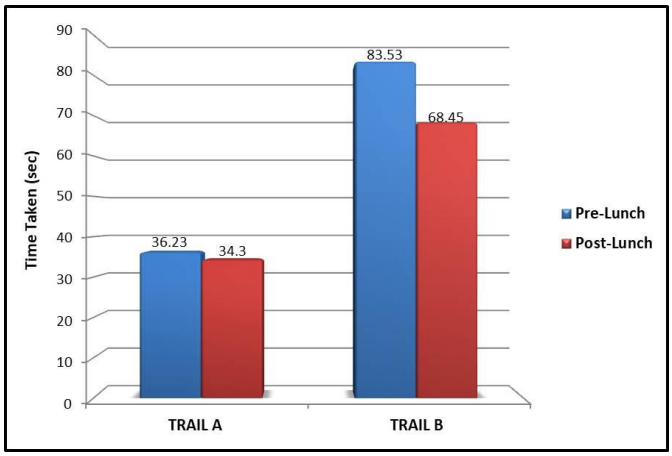


Figure - 5: Comparison of Pre- and Post- Lunch time taken for Trail A and Trail B test.



Distribution of subjects was also explored based on their MMSE score. As shown in **Figure - 4**, all the participants had MMSE score ≥ 25.

Figure - 5 illustrates the difference in time taken for completing Trail A and Trail B test before and after having afternoon meals. Post-lunch time taken for completing the tests was found to be less and the difference was statistically highly significant ($p < 0.01$) for the trail B test.

Discussion

Cognition forms the basis of human perception, behavior and adaptability. Morning (breakfast), afternoon (lunch) and evening (dinner) meals regulate the glycemic levels in our blood and have a gross impact on the neuronal functioning

and memory circuits. Memory, reasoning, attention and psychomotor co-ordination depend on multiple factors like nutrition, years of education, motivation, fatigue and time of the day etc. [8].

The neuroplasticity mechanisms underlying cognitive and behavioral alterations particularly neuronal alterations in hippocampus and pre-frontal cortex are essential for encoding memories and controlling our behavior [9].

A number of complex factors affect cognitive performance depending at any particular moment. Brain is sensitive to metabolic changes associated with pattern of meals and fasting and also long-term nutritional status, glucose being the main fuel of the brain. Very few nutritional effects on cognition have received scientific support [8]. Beneton (1996) have stressed the importance of neurotransmitters like noradrenaline, acetylcholine and serotonin which are also dependent on glucose metabolism, are essential for fine motor skills and cognitive processes. Poor diet is a potential risk factor for the development of cognitive impairment; conversely dietary nutrients are protective against such impairments [10]. On the other hand, excessive consumption of certain dietary components is associated with reduced global cognitive function, cognitive decline, and dementia.

Consumption of lunch shows widespread variant patterns in different demographic patterns. There are studies which evaluated the effect of lunch in reference to lunch skipping, lunch size and lunch composition. It was seen that some aspects of cognition were impaired in early afternoon after consuming lunch and large lunch size also had a negative impact [11]. Macronutrient composition of lunch (carbohydrates, fats and proteins) also affected different cognitive functions as assessed by different cognitive tasks**.** Studies have revealed that high protein meals lead to increased distractibility whereas high carbohydrate meals lead to slowing of reactions times [12].

Endogenous biological rhythms may also have an effect on cognition after meals [13]. Individuals tend to be more alert in the early part of the day and may suffer from a decreased alertness and efficiency around 2 pm.[14] Similarly, studies conducted in the laboratory have found that a drop in performance of mental tasks often is reported approximately 1 hour after consuming lunch and may take several hours to return to the pre-lunch state.[15,16] Some studies indicate that mental abilities at midday are impaired to a greater degree in individuals who have consumed lunch than in those who have not, indicating that food intake does contribute to the post-lunch dip [15-17].

In our study, performed on 80 healthy individuals (40 males and 40 females) with age group 18-60 years and tested (Trail A and Trail B test) after one hour of consumption of lunch which was of mixed nature (macronutrients), cognitive performance was found to be improved. There were significant changes recorded post-lunch which showed a definitive improvement in terms of time taken to finish the task (**Figure - 5**). So, we concluded that post-lunch, some components of cognition show improvement.

Our results are in corroboration with some studies which have shown similar findings. Some studies have shown improvement after consumption of afternoon meals. In one study subjects with higher glucose tolerance showed improved cognitive tests ($P<0.05$). They performed better in the working memory test at 90 min ($P<0.034$) and after the simulated low-glycemic index (GI) breakfast compared with the simulated high-GI breakfast. Possibly, the cognitive functions might be enhanced by avoiding a sharp decline in blood glucose concentration and by maintaining a higher glycaemia in the late postprandial period [18].

Kanarek (1997), Kanarek and Swinney (1990) have suggested that intake of carbohydrate rich snack in the afternoon can improve cognitive performance in the adults [19, 20]. Schroder et al. (2015) have indicated that lunch intake is

beneficial for updating the working memory which may be due to increased cortisol levels post-lunch [21].

Many of the recorded literature sources however have reported that there is a dip in post-lunch cognition levels. Craig, et al. (1981) examined the lunch affected the efficiency of perceptual discrimination. This measure was chosen because of the significance to many work-related tasks. Participants performed this task before and after eating a three-course lunch and or having no lunch. The authors concluded that consumption of lunch is an important precursor for the post-lunch dip in performance [17].

Although there is not a clear consensus of how mixed meals affect performance, several mechanisms have been considered, including increase in the level of blood glucose and individual effects of macronutrients on neurotransmitter synthesis. Although it is hard to determine how macronutrients affect performance when studied in mixed meals rather than tests of single nutrients, mixed-meal studies are valuable in that represent the way people normally eat.

The above studies however are in contrast to our findings. The possible reasons for improvement in post-lunch cognition in our study might be due to the following reasons:

Most of the employees were class III and class IV workers who normally consume a more carbohydrate rich diet in their mixed meal (like chapattis, rice, potatoes, etc.)

They were allowed to follow their normal routine before and after lunch like drinking tea, coffee and smoking.

The paper and pencil tests like Trail test are subjective in nature and improvement might be due to repetition and better understanding when done for the second time by the subjects.

Last but not least, the glycemic levels in the blood may be more stabilized after consumption of such a diet (after one hour).

To further support the findings of our study, large scale population-based studies taking into account different demographic parameters should be designed.

Conclusion

In our study to analyze the effect of afternoon meals (during lunch hours) on cognition in general Indian working population we found that there is significant improvement in the working memory and executive control of brain as deciphered by administering Trail making tests (A and B). Thus, we can postulate that having a proper lunch in terms of size and proportion of macro- nutrients (mixed diet) and that too at a proper lunch time improves our cognitive functioning and may increase working efficiency at designated work places.

Abbreviations

MMSE – Mini mental state examination
TMT – Trail making test

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