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Research Article

Influence of Breakfast on Mental Ability and Correlation with Protein Intake: A Case-Control Study

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Abstract

Mental functions represent the activity status of the brain and are assessed to understand mental ability. In qualitative term, the sum of mental abilities is referred to as 'intelligence'. A steady blood glucose level is the prerequisite for optimum brain function. Thus the importance of breakfast after a night long fast is immense. Brain tissue consumes additional glucose during challenging mental tasks. The present study assessed mental abilities using 'Arithmetic Test' and 'Matrix Test' in addition to Academic performance taking two groups of young boys (10-12 yrs.) under given experimental conditions referred to as 'with breakfast' and 'without breakfast'. The results of mental functions with and without breakfast corroborate with earlier reports suggesting a positive correlation of blood glucose with mental ability. The study further confirms a positive correlation of dietary protein intake with mental ability of the study population.

Keywords: Mental Ability; Breakfast; Protein Intake; Logistic Regression

Introduction

Mental abilities are representatives of the faculty that enable an individual to judge, comprehend, and deal with people, objects, and symbols. It also makes people understand their environment [1]. 'Intelligence' is the term that refers the quality of a person possessing optimum mental abilities [2]. Mental functions driven by the brain [3] are customarily assessed to evaluate mental ability [4]. Functions of brain tissues depend on its uninterrupted supply of glucose [5]. Since nervous tissue cannot store glucose therefore, it largely depends on the readymade supply of glucose from blood [5]. A steady blood glucose level thus is important to avoid any functional dysregulation of the brain. In this context, from the nutritional point of view, breakfast is most likely to carry immense strategic importance after a night long (~10h) fast as it most importantly supplies glucose beside other macro and micro nutrients to the blood and prevents possibility of low blood glucose level due to overnight fasting. Among children the positive correlation of blood glucose level with the learning process [6] suggests breakfast influences brain function; though results of such reports are largely based on acute effects of breakfast on cognitive performance [7]. Principal outcome of the papers presented at the International Symposium on Breakfast and Performance in Napa, CA, suggest a positive effect of breakfast on working memory compared to the performance after overnight fasting [8]. Studies have revealed that a decline in blood glucose level has been found to affect attention, memory and learning, and these aspects of cognitive function are enhanced on glucose administration [6]. Moreover, the brain tissue uses up additional glucose during challenging mental tasks [9,5]. Therefore, consuming regular meals (meaningfully and optimally spaced) may help maintaining optimum blood glucose level which is required for good cognitive function [10]. The work of Craft., *et al*. [11] has demonstrated the importance of glucose regulation on performance of memory task independent of age and discrete population. They reported equivalent performance on a memory task of young males with poor glucoregulation to older men with good glucoregulation. While numbers of available reports suggest a possible correlation of breakfast with mental ability among subjects of different age groups, no study has reported conclusively if average dietary protein intake has any observable modulatory effect on mental ability of young children either with breakfast or without breakfast.

In connection to the present working population skipping breakfast was observed being common among young children attending schools in the morning shift (6.30am to 11am). The reasons of skipping breakfast were many starting from late rising in the morning to voluntary avoidance (don't feel like/not important and so on). Making parents aware of the importance of breakfast did not even work significantly well because in most instances parents upheld their children's excuse. The present study has been designed to assess the effect(s) of skipping breakfast on mental ability of young boys studying in the fifth grade in a district town of West Bengal, India. The study also investigates the modulatory effect of age-matched optimum protein intake on mental ability, if any, of the participating subjects. Since no study has been carried out earlier involving subjects of the present working area and environment, the authors hypothesize that skipping breakfast will negatively affect mental ability and the quantity of daily average protein intake might have some influence on mental ability of young children apart from the effect of breakfast as reported earlier [7]. The study will definitely add more to the existing knowledge exploring if demographic differences stand causal to any significant difference in observed responses in addition to the potential role of protein intake, if any, on mental ability in children.

Materials and Methods

Subjects

The present study recruited school going older children (boys) aged between 10-12 yrs. (studying in 5th grade). A total of 137 participants were picked up randomly from the morning section of two local government aided schools in the district of Murshidabad of the state of West Bengal, India. The socioeconomic status of the students was assessed by Kuppuswamy's socio-economic scale [12,13]. For testing the reliability of participation students were asked to answer a questionnaire and assessed on a 5-point scale. Those who scored 4 and above were only selected for participation (Figure 1). Before start of the work, necessary permissions were obtained from the school authorities. The final participating students (N = 78) (Figure 1) were divided into two groups of 39 each. Participants were briefed about the study and their parents met to discuss the aim of the study. On the days of the study Students prefixed as Group-A was asked to attend the test after having a standard breakfast of Butter toast (2Pcs), boiled egg (one) and sweet (one) in the morning (Group 'with breakfast'). The other group (Group-B; 'without breakfast') was asked to come for the test without having breakfast. Both the groups were asked to take their dinner at 9pm on the night before the day of the mental ability test. On the scheduled dates the two groups of students were made to take their allotted seats at 7.30 am on two separate halls (marked A and B respectively) and were given the same problems to solve within given time. The question had two parts – (i) Arithmetic problem solving and (ii) matrix analysis which consisted of test of reasoning. Similar assessment was done for two consecutive days and the mean scores were considered.

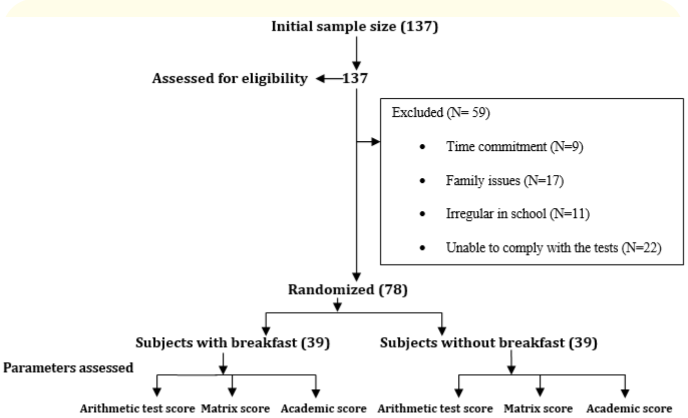

Figure 1: Flow of subjects through the study. Number in the parenthesis indicates sample size in respective category.

Assessment

- **Age:** This was obtained from the register of the school.
- **Height:** Height in centimeters was measured with an anthropometer with shoes removed and standing on a horizontal platform with heels close together stretching upward to the fullest extent with arms hanging on the sides and heels and buttocks touching against the rod. The head was aligned in Frankfurt plane. The horizontal scale of the anthropometer was brought down and held against the top of the head and the readings were taken to the nearest 1 cm [14].
- **Weight:** Weight was measured in kg by using a weighing machine. It was calibrated against known weights regularly. Weight was taken with minimum clothing and without shoes and was recorded to the nearest 500 grams [15].

Calorie consumption

The calorie consumption by individual subject was assessed from the estimation of food and nutrient intake, i.e., Diet Survey. The Diet Survey was carried out following three 24h Recall Method as described by Gibson and Ferguson [16,17], and validated by Yunsheng., *et al.* [18].

Physical activity level (PAL)

Physical activity level (PAL) was assessed by following the standard questionnaire where the subjects' self-reported average daily activities in 24h were recorded and then the average energy expenditure of each individual in performing the different activities for 24h was calculated following the method as described by Bharathi., *et al.* [19]. The method followed was by factorial estimation of total energy expenditure and physical activity level [20].

Mental ability

- **Arithmetic Test Score (Verbal Intelligence):** In order to determine the subjects' competence in mathematics, the Woodcock-Johnson III Subtests of Achievement (WJ III) [21] was used. Each boy was required to complete the Math Fluency and Calculation subtests. The Calculation subtest measures skills in mathematical computations. The individual is required to perform addition, subtraction, multiplication and division and combinations of these operations. There is no time constraint. The Math Fluency test assesses one's ability to quickly solve simple arithmetic problems. The participant is given three minutes to complete as many addition, subtraction and multiplication problems as possible. It should be noted that neither of the subtests contained any item that required numerical comparison [22].
- **Matrix Test (Nonverbal Intelligence):** Raven's Progressive Matrices, 1938 [23] was followed to test reasoning skill of the subjects. The test comprises of meaningless figures presented for observation to establish the relations between them. While doing it was important to conceive the nature of the figure completing each system of relations presented, and, by so doing, it was required to develop a 'systematic-method of reasoning' [23]. The scale-consists of 60' problems divided

into five sets of twelve (12) in each set. The first problem is as nearly as possible self-evident. The problems which follow become progressively more difficult With the Mill Hill Vocabulary Scale. Progressive Matrices [23] has been used to study normal changes in the recall of information and in present cognitive activity between 6 and 63 years of age [23].

- **Academic Score:** In this study, annual report cards of class V of each participant were collected. Each report card showed marks of examinations held after 3 months (quarterly examination), 6 months (half-yearly examination) and 12 month (annual/term-end examination). Average of the sum total marks obtained in all the three examinations held throughout the year was considered as the academic score for each student.

Statistical analysis

Demographic characteristics, like height, weight and BMI were expressed as mean± SEM. Significance of difference of the test scores (ATS, MTS and Academic Score) between the subjects with breakfast and without breakfast, were assessed using student's t-test [24].

The significance of difference between the mean scores of Arithmetic and Matrix Test, within relevant groups with respect to their protein intake (g/day) was computed using one-way analyses of variance (ANOVA) followed by post-hoc Tukey's HSD test [25]. In all cases differences were considered significant if $p < 0.05$.

Binomial logistic regression analysis [26] Test results were used as response variables whereas protein intake was used as predictors in the logistic regression models. Linear correlation coefficient was calculated between protein intake (g/day) and Academic Score. Differences were considered significant if $p<0.05$. All statistical analyses were done using SPSS (SPSS Version 20.0, SPSS Inc., Chicago, IL).

Results

Parameters Observed	Subjects under given experimental condition	
	With breakfast (N = 39)	Without breakfast (N=39)
Age (yrs.)	10.57 ± 0.12	10.49 ± 0.09
Height (cm)	137.39 ± 0.85	135.17 ± 1.24
Weight (kg)	40.52 ± 0.83	41.07 ± 0.92
BMI (kg/m^2)	21.52 ± 0.38	21.35 ± 0.31
Energy intake (kcal)	2078.00 ± 45.04	1882.90± 51.05
SES (Score = 17; category- Upper middle)		

Table 1: Demographic characteristics of the study population.

Results are expressed as mean ± SEM.

(N) represents number of subjects in each group.

Energy requirement (RDA) of the population studied is 2190 kcal/d.

SES, Socioeconomic scale.

Table 1 describes the demographic characteristics and anthropometric parameters of the study subjects. The subjects were categorized into two groups namely "With Breakfast" and "Without Breakfast", based on the experimental pre-condition. Mode of grouping implies that one group was allowed to have their usual breakfast before participation in the mental ability tests and the other group was asked to skip their breakfast before the tests.

Table 2 and figure 2 show the mental ability scores [represented by the Arithmetic Test Scores (ATS) and Matrix Test Scores (MTS)] and the academic scores of the participants in both groups. The results (Table 2 and figure 2) reveal that the mean ATS and MTS of the students "without breakfast" were significantly lower ($p < 0.001$ and $p < 0.01$ respectively) compared to the scores of the students "with breakfast." However, table 2 and figure 2 show no significant difference ($p > 0.05$) in the mean academic performance between the two study groups.

Study Groups	Test Variables		
	ATS	MTS	Academic Score
With breakfast (N = 39)	36.30 ± 1.95	6.40 ± 0.37	278.66 ± 8.5
Without breakfast (N = 39)	26.66 ± 1.84^a	5.10 ± 0.51^b	281.85 ± 7.9

Table 2: Test scores and Academic scores of the study subjects.

Results are expressed as mean ± SEM.

(N) represents number of subjects in each group.

ATS, Arithmetic Test Score.

MTS, Matrix Test Score and

Academic Score represents the average of marks scored in the mid-yearly and terminal examination.

Significantly different from with breakfast (a) $^a p < 0.001$ (b) $^b p < 0.01$.

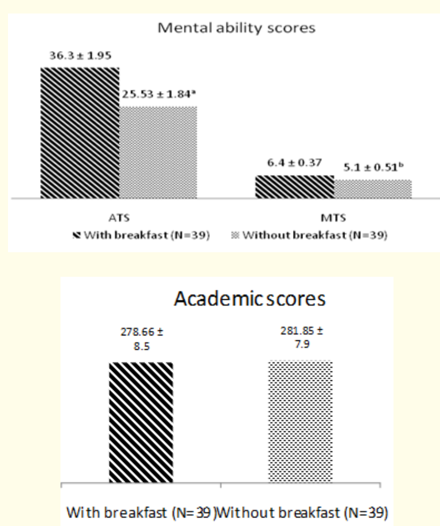

Figure 2: Mental ability scores (ATS and MTS) and Academic scores of study subjects.

Condition	Category	Mean Score		Mean Protein Intake (g/day)
		ATS	MTS	
With breakfast (N = 39)	↑ Average (N = 34)	40.73 ± 0.60	7.03 ± 0.27	46.95 ± 2.85
	↓ Average (N = 05)	6.20 ± 0.65^{a}	3.0 ± 0.31^{d}	23.54 ± 1.55^{g}
Without breakfast (N = 39)	↑ Average (N = 06)	44.16 ± 0.65^{b}	8.33 ± 0.30^{e}	44.15 ± 2.69^{h}
	↓ Average (N = 33)	$22.15 \pm 1.28^{a,b,c}$	$4.5 \pm 0.33^{d,f}$	$33.20 \pm 0.73^{g,h,i}$

Table 3: Arithmetic and Matrix Test Scores and Protein Intake of the subjects.

Results are expressed as mean ± SEM.

(N) represents number of subjects in respective categories.

ATS, Arithmetic Test Score; MTS, Matrix Test Score.

50% of the total score is the cut off value to categorize above (↑) and below (↓) average.

Significantly different from: (a) ATS with breakfast and (↑) Average $^{a}p < 0.001$; (b) ATS with breakfast and (↓) Average $^{b}p < 0.001$; (c) ATS without breakfast and (↑) Average $^{c}p < 0.001$.

Significantly different from: (a) MTS with breakfast and (↑) Average $^{d}p < 0.001$; (b) MTS with breakfast and (↓) Average $^{e}p < 0.001$; (c) MTS without breakfast and (↑) Average $^{f}p < 0.001$.

Significantly different from (a) Protein intake with breakfast and (↑) Average $^{g}p < 0.001$; (b) Protein intake with breakfast and (↓) Average $^{h}p < 0.001$;(c) Protein intake without breakfast and (↑) Average $^{i}p < 0.001$.

Table 3 and figure 3 represent the mean Arithmetic and Matrix Test scores (ATS and MTS) respectively achieved by the participants in each of the two groups along with their mean protein intake (g/day). Based on scores, subjects with and without breakfast were further sub-categorized into 'above average' (↑Average) and 'below average' (↓Average). Fifty percent (50%) of the total marks allotted were considered as the cut-off value securing above and below which was the basis for categorization into (↑ Average) and (↓ Average).

Results of table 3 and figure 3 also elaborate those 34 students out of 39 appearing in the arithmetic and matrix tests 'with breakfast' scored above average (↑Average) and 5 students in the same group scored below average (↓Average). On the other hand, in the remaining group i.e., 'without breakfast' 6 students out of 39 scored above average (↑Average) while 33 students scored below average (↓Average). While a significant difference in ATS ($p < 0.001$) prevails between the below average achievers of the two groups ("with" and "without" breakfast), no such difference in their MTS ($p > 0.05$) is observed.

Figure 3: Arithmetic and Matrix Test Scores and Protein Intake of the subjects.

When average protein intake (g/day) was calculated from dietary intake of the participants it was observed (Table 3 and Figure 3) that those who scored above average (↑Average) in both Arithmetic and Matrix tests consume protein in the range of 44.15-46.95g/day; on the contrary those who scored below average (↓Average) in both the tests had an average protein consumption ranging between 23.54-33.20g/day. Students who scored above average (both in AT and MT) showed significantly higher ($p < 0.001$) mean protein intake compared to those scored below average despite their breakfast intake status (Table 3 and Figure 3). Similarly, ignoring the issue of intake of breakfast, students in the (↓Average) category who still scored significantly higher ($p < 0.001$) showed a concomitant higher mean protein intake (Table 3 and Figure 3) than the rest who scored (↓Average) in AT but not in MT ($p > 0.05$) (Figure 3).

Discussion

The present study aims to examine the influence of blood glucose level, if any, on mental ability of a small randomly chosen sample consisting of young school children (10-12 yrs.) in the state of West Bengal, India. Selection of working population in the present study is different and novel in view of the place, religion, culture, social environment etc. when compared to the study population of the earlier reports [27,28]. The present work also aims to evaluate if daily protein intake has any modulatory role on mental ability of the participating subjects. Lack of significant difference of values of the observed demographic and anthropometric parameters between the groups labeled 'with breakfast' and 'without breakfast' (Table 1), confirms unbiased and uniform selection of subjects.

Significant difference in mental ability test scores between groups under two given experimental conditions 'with' and 'without' breakfast (Table 3) corroborate with earlier findings [29-31] though the present work was carried out on a different population. The results suggest a more close affiliation of blood glucose level on brain functions. Identical socioeconomic status of the subjects minimized the possibility of family environment as a predictor. Reasons for no significant difference in academic performance of the study subjects (Table 2 and Figure 2) under categories of 'with' and 'without' breakfast may be multifactorial: (a) The test procedures adopted may be too much student friendly; (b) Syllabus on which examinations are conducted may not be adequate for discrimination of mental ability; (c) Question pattern may lack provision of intellectual thinking and few more such possibilities cannot be overruled.

It is expected that a difference in academic performance of the participants under two given experimental conditions (With and without breakfast) is likely to surface if the different term-end examinations introduce thought type questions, because solving such questions are more likely to be linked with mental ability [7].

Results of table 3 and figure 3 show a probable correlation between test scores and protein intake of 10 to 12 years old participants. In the present study protein intake has been calculated from the nutritional survey data. The observed fact is that, participants who consume less protein habitually take food of poor quality compared to those whose protein intake is relatively higher. No specific reports are available yet explaining the direct link of protein intake with mental health; however consistent cross-sectional associations have been observed between unhealthy dietary patterns and worse mental health in childhood or adolescence [32-35]. The present study intends to test the hypothesis of a positive correlation, if any, between protein intake and mental health where the latter is expressed through assessment of mental ability [4]. The rationale behind such investigation lies in the necessity of protein behind brain development [36,37] Validation of the hypothesis is apparently confirmed from the results of the present study as evident on further segregation of the study population (Table 3). Results show that fewer participants 'without breakfast' and 'with breakfast' who scored respectively high and low in mental tests apparently violate the earlier explanation [6]. On the other hand in view of the mean protein intake by the two smaller 'out of the trend' groups who scored higher though 'without breakfast' and who scored lower though 'with breakfast' exhibit significantly higher and lower protein intake respectively in their diet (Table 3 and Figure 3). Revisiting the results minimize doubt regarding the importance of dietary protein in augmenting mental ability. It is well accepted that mental activity is intimately associated with the structural integrity and functions of the brain [38-40]. Protein in the brain is a known structural molecule as well as a functional entity [36,37]. Reports that poor diet negatively affects mental health [32-35] are indirect support to the present observation.

Results of logistic regression analysis of table 3 as presented in table 4 reveal that protein intake significantly affected the outcome of occurrence of mental ability status in a negative manner (i.e., number of subjects with below average ATS and MTS score decreased with higher protein intake). It may also be worth mentioning that the independent variable namely protein intake, was found to be a stronger predictor of mental ability status. In the present model chi square has one degree of freedom, a value of 54.379 and $p < 0.001$ for mental ability (Table 4) indicating that the model had a poor fit, with the model containing only the constant suggesting that the predictor had a significant effect and created essentially a different model. Well-fitting models showed non-significance on the H-L goodness-of-fit test. This desirable outcome of non-significance indicated that the model prediction did not significantly differ from the observed results (Table 4). In the present analysis H-L statistic had the significance of 0.422 for ATS and MTS (Table 4), which indicated statistically not significant and therefore, the present models were quite good fit. Nagelkerke's pseudo R^2 value of 0.669 (Table 4) for ATS and MTS indicated a moderately strong relationship of 66.9% between predictor and prediction of mental ability status.

Independent Variable	**Dependent variables**				
	Mental Ability Scores (ATS and MTS)				
Risk factor	B	SE	OR*	CI*	P
Protein Intake	-0.356	0.080	0.701	0.599, 0.819	<0.0001
Nagelkerke's Pseudo R^2	0.669				
Model $_{x^2}$	54.379, df = 1, p < 0.0001				
H and L*Test	p = 0422				
N*	= 78				

Table 4: Logistic regression Analysis of the effect of independent variable (Protein intake)

on mental ability scores (ATS and MTS) of human male subjects.

*OR, odds ratio;

CI, confidence interval.

H and L, Hosmer and Leeshawn.

N, study population.

Independent Variable	**Dependent variable**	
	Academic Score	
	Pearson Correlation	**p value**
Protein intake	0.112	> 0.05

Table 5: Study of the direction and strength of association between Independent and dependent variables using Pearson correlation.

Pearson correlation statistical analysis (Table 5) [41] determines the association of individual predictor (protein intake) with the dependent variable (academic score), (a) a correlation between academic score and individual predictor namely, protein intake r (77) = 0.112, $p > 0.05$ (b) association of Academic score with protein intake (0.112) is weak and (c) correlation between academic score and protein intake is positive.

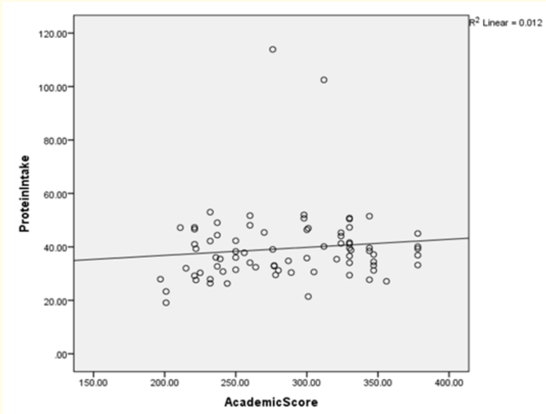

Figure 5: Scatter plot of Academic Score and Protein Intake.

Conclusion

The present study concludes that blood glucose level is an important determinant of mental ability since it serves as the most important ready energy supplier to the brain tissue that controls mental health. Hence the importance of breakfast after 9-10h night long fast is implied. Over and above the importance of proteins in the context of the present work is ushering. This may be due to the fact that proteins are not only the vital structural molecules of the brain but they also serve as discrete functional entity in the brain tissue.

The sample population though unbiased still not large enough to provide a ground for emphatic articulation of the findings. It is desirable that such a novel finding be reassessed on a larger population.

Declarations

Ethics Approval and Consent to Participate

Formal ethical permission was not required for the study did not have any medical intervention. However, necessary permission was sought from the school authority and consent was taken from each participant prior to the interview. The entire test procedure and the aim of the study were discussed with the guardians of each participant.

Consent for Publication

Not applicable. The article does not include a clinical study.

Availability of Data and Material

The data sets used were collected by the first and the second authors.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

AD and SK worked in the field and contributed in collection of data. AD and SKG contributed in analyses of data. AD did the statistical analysis. SKG prepared the manuscript with AD. SKG made the final corrections of the manuscript.

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Bibliography

1. Deary IJ. "Differences in mental abilities". *BMJ (Clinical Research Edition)* 317.7174 (1998): 1701-1703.
2. Anwar E. "A Study of Reasoning Ability of Secondary School Students in Relation to Their Intelligence". *IOSR Journal of Humanities and Social Science (IOSR-JHSS)* 20.5 (2015): 29-31.
3. Poldrack RA., *et al*. "Discovering Relations Between Mind, Brain, and Mental Disorders Using Topic Mapping". *PLOS Computational Biology* 8.10 (2012): e1002707.
4. Colom R., *et al*. "Human intelligence and brain networks". *Dialogues in Clinical Neuroscience* 12.4 (2010): 489-501.
5. Mergenthaler P., *et al*. "Sugar for the brain: the role of glucose in physiological and pathological brain function". *Trends in Neurosciences* 36.10 (2013): 587-597.
6. Ciolacu MV and Chraif M. "The Relationship between Blood Glucose Levels and Performance at Cognitive Processing and Motor Coordination Tasks". *Procedia - Social and Behavioral Sciences* 187 (2015): 777-782.
7. Adolphus K., *et al*. "The effects of breakfast on behavior and academic performance in children and adolescents". *Frontiers in Human Neuroscience* 7 (2013): 425.
8. Pollitt E and Mathews R. "Breakfast and cognition: an integrative summary". *The American Journal of Clinical Nutrition* 67.4 (1998): 804S-813S.
9. Huffcutt AI and Culbertson SS. "Interviews. In S. Zedeck (Ed.), APA handbooks in psychology®. APA handbook of industrial and organizational psychology, Vol. 2. Selecting and developing members for the organization". *American Psychologica Association* (2011): 185-203.
10. Wenk GL. "An hypothesis on the role of glucose in the mechanism of action of cognitive enhancers". *Psychopharmacology* 99 (1989): 431-438.
11. CRAFT S., *et al*. "The effects of hyperglycemia on memory and hormone levels in dementia of the Alzheimer type: A longitudinal study". *Behavioral Neuroscience* 107 (1993): 926-940.
12. Kumar N., *et al*. "Kuppuswamy's socioeconomic scale: Updating income ranges for the year 2012". *Indian Journal of Public Health* 56.1 (2012): 103.
13. Tabassum N Rao R. "An updated Kuppuswamy's socio-economic classification for 2017". *International Journal of Health Sciences and Research* 7.5 (2017): 365-367.

14. McDowell., *et al*. "National Health and Nutrition Examination Survey, NHANES, Anthropometry Procedure Manual, CDC (2005).

15. National Health and Nutrition Examination Survey, NHANES, Anthropometry Procedure Manual, CDC (2007).

16. Gibson RS and Ferguson EL. "International life sciences institute. An interactive 24-Hour recall for assessing the adequacy of iron and zinc intakes in developing countries. Washington, D.C". *International Life Sciences Institute* (1999).

17. Dietary assessment: a resource guide to method selection and application in low resource settings. FAO. Rome (2018).

18. Yunsheng MA., *et al*. "Number of 24-hour diet recalls needed to estimate energy intake". *Annals of Epidemiology* 19.8 (2009): 553-559.

19. Bharathi AV., *et al*. "The development and characteristics of a physical activity questionnaire for epidemiological studies in urban middle class Indians". *Indian Journal of Medical Research* 111 (2000): 95-102.

20. Food and Agriculture Organization of the United Nations, United Nations University, World Health Organization, eds. Human energy requirements: report of a Joint Fao/Who/Unu expert consultation: Rome, 17-24 October 2001. Rome: food and agricultural organization of the United Nations (2004).

21. Judith M Dean., *et al*. "Measuring Vertical Specialization: The Case of China". *Review of International Economics* (2011): 609-625.

22. Mather N., *et al*. "Perceptions and knowledge of preservice and in service teachers about early literacy instruction". *Journal of Learning Disabilities* 34.5 (2001): 472-482.

23. Raven J. "Manual for Raven's Progressive Matrices and Vocabulary Scales". Research supplement no. 1: The 1979 British standardisation of the Standard Progressive Matrices and Mill Hill Vocabulary Scales, together with comparative data from earlier studies in the UK, US, Canada, Germany, and Ireland. Oxford, England: Oxford Psychologists Press/San Antonio, TX: The Psychological Corporation (1981).

24. Feng Y., *et al*. "The application of Student's t-test in internal quality control of clinical laboratory". *Frontiers in Laboratory Medicine* 1.3 (2017): 125-128.

25. Francisco de AS e S and Carlos AV de A. "Comparison of means of agricultural experimentation data through different tests using the software". *African Journal of Agricultural Research* 11.37 (2016): 3527-3531.

26. Bursac Z., *et al*. "Purposeful selection of variables in logistic regression". *Source Code for Biology and Medicine* 3.1 (2008): 17.

27. Azari NP. "Effects of glucose on memory processes in young adults". *Psychopharmacology* 105 (1991): 521-524.

28. Benton D and Owens DS. "Blood glucose and human memory". *Psychopharmacology* 113 (1993): 83-88.

29. Zahedi H., *et al*. "Breakfast consumption and mental health: a systematic review and meta-analysis of observational studies". *Nutritional Neuroscience* (2020): 1-15.

30. Begdache L., *et al*. "Assessment of dietary factors, dietary practices and exercise on mental distress in young adults versus matured adults: A cross-sectional study". *Nutritional Neuroscience* 22.7 (2019): 488-498.

31. Smith AP. "An investigation of the effects of breakfast cereals on alertness, cognitive function and other aspects of the reported well-being of children". *Nutritional Neuroscience* 13.5 (2010): 230-236.

32. O'Nei A., *et al*. "Relationship between diet and mental health in children and adolescents: a systematic review". *American Journal of Public Health* 104.10 (2014): e31-e42.

33. Molteni R., *et al*. "A high-fat, refined sugar diet reduces hippocampal brain-derived neurotrophic factor, neuronal plasticity, and learning". *Neuroscience* 112.4 (2002): 803-814.

34. Jacka FN., *et al*. "A prospective study of diet quality and mental health in adolescents". *PLoS One* 6.9 (2011): e24805.

35. McMartin S., *et al*. "The association between diet quality and internalizing disorders in children". *American Journal of Epidemiology* 173 (2011): S289-S289.

36. Cormack BE and Bloomfield FH. "Increased protein intake decreases postnatal growth faltering in ELBW babies". *Archives of Disease in Childhood. Fetal and Neonatal Edition* 98 (2013): F399-404.

37. Stephens BE., *et al*. "First-week protein and energy intakes are associated with 18-month developmental outcomes in extremely low birth weight infants". *Pediatrics* 123.5 (2009): 1337-1343.

38. Gardner H. "Frames of Mind: "The Theory of Multiple Intelligences". *New York, NY: Basic Books* (1993).

39. Mills KL., *et al*. "Developmental changes in the structure of the social brain in late childhood and adolescence". *Social Cognitive and Affective Neuroscience* 9 (2014): 123-131.

40. Piaget J., *et al*. "The Child's Conception of the World". *London: Paladin* (1973).

41. Mukaka M. "A guide to appropriate use of correlation coefficient in medical research". *Malawi Medical Journal* 24.3 (2012): 69-71.