ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/365383309

Nutrition and Cognition in School-Aged Children: A Brief Review

Article · November 2022

CITATION
1

READS
1,274

1 author:

Yetunde Ojo
Bowen University
20 PUBLICATIONS **4** CITATIONS

SEE PROFILE

All content following this page was uploaded by Yetunde Ojo on 15 November 2022.

The user has requested enhancement of the downloaded file.

Benchmark Journals

INTERNATIONAL JOURNAL OF EDUCATIONAL BENCHMARK (IJEB),
eISSN: 2489-0170 pISSN:2489-4162 University of Uyo

Nutrition and Cognition in School-Aged Children: A Brief Review

Ojo, Yetunde Abiola, Ph.D
Department of Counselling and Human Development Studies,
University of Ibadan
Ojoyetty33@yahoo.com

Abstract

Children are the future of every nation. Community and national development is greatly influenced by the level of education of its citizens. There is an increasing body of literature that suggests a link between adequate nutrition and optimal brain function. This paper briefly describes the research carried out on the impact of nutrition on cognitive functions and school performance. This became imperative because in the present contemporary world, student academic performance is nothing to write home about, parents and educators have long searched for answers on the relationship between what children eat and their test scores. Thus, an in-depth understanding of the nature of relationship that exists between nutrition and cognition is important to create appropriate population-based dietary policies for child nutrition. This paper reviewed relevant literature on nutrition and brain function, nutrition in school-aged children as well as its impact on cognitive development and education. It was concluded that the role nutrition plays in academic performance cannot be over-emphasized. It was finally recommended among others that free school feeding programmes should be made available for school children at all levels. Also, nutrition education programmes and counselling should be included in the school curriculum.

Key Word: Nutrition, Cognition, Children and School Performance

Introduction

In recent years, researchers have shown increasing interest in looking at the impact of nutrition on academic performance. Children of today would later become functioning members of the society. Their health, academic achievement and attainment are major determinants of the economic growth and overall progress of the nation. The early years of life is a time of rapid brain development which includes neural plasticity, working memory, attention and inhibitory control. Poor nutrition during the formative years could have irreversible consequences. According to UNICEF (2013), about one third of under-five aged children mortality is attributable to under-nutrition and 165 million children in the world under the age of five are afflicted by stunting. For millions of children, it means they are

forever, stunted, smaller than their non-stunted peers. It is estimated that over 200 million children under 5 years of age in the developing world have significantly impaired growth.

In a study carried by Kreb-Smith, Guenther, Subar, Kirkpatrick and Dodd (2010), more than 90% of children aged 4 to 18 did not meet recommendations for vegetable intake and more than 75% did not meet guidelines for fruit intake while more than 90% of children consume more than the recommended amounts of solid fats and added sugars. The Youth Risk Behaviour Surveillance System conducted a research and found that the number of children and adolescents who are not eating the recommended daily amounts of fruits and vegetables to be 76.1%, with 82% not drinking the daily recommended amount of milk (Engle,2010). The centre for Disease Control and Prevention in 2012 asserts that more than one-third of children and adolescents aged 6 to 19 was considered overweight and obese yet, many children's diets lack micronutrient. This is an indication that malnutrition exists among school-aged children which is a violation of child's right.

Ogannah (2015) assert that schooling builds human capital - skills, abilities, and resources which ultimately shapes health and well-being. Considering the amount government invests yearly on education, it is very disheartening that Nigeria is far behind in academic performance compared with other developing countries of the world with similar economic development. There are many reasons for this poor academic performance; poor nutrition may be a contributing factor. And since high academic achievement could lead to economic growth and development, hence, inadequate nutrition during childhood may result in more serious problems than expected. It may also lead to the nation's low output and low socioeconomic status of citizens thereby hindering the overall development of the nation.

According to Levinger (1996), vast numbers of school-aged children in developing countries face major health and nutrition problems that adversely affect their ability to take advantage of the limited educational opportunities available to them. Brown, Beardslee and Prothrow-Stith (2008) noted that poor nutrition can leave students' susceptible to illness or lead to headaches and stomach aches, resulting in school absences. Also, UNICEF (2013) identified slower memory recall, hyperactive and attention problems, lower test scores and class repetition as consequences of malnutrition. Diets high in trans and saturated fats can negatively impact learning and memory, students' thinking skills, behaviour, and health, nutritional deficiencies early in life can affect and the overall cognitive development of

school-aged children (Tara,2005). Thus, access to proper nutrition improves students' cognition, concentration, and energy levels. Ogannah (2015) submitted that chronic malnutrition experienced during early life inhibits growth, retards mental development, and reduces motivation and energy level, causing a reduction of educational attainments and delay in school entry. In principle therefore, nutritional problems in the school-aged child may carry into adulthood thereby enabling them to be prone to adult diseases such as ischemic heart disease, hypertension, some types of cancer and diabetes (Lahey and Rosen 2010).

Keeping all this in view, it becomes imperative to understand the role of specific nutrients in the development of cognitive functions of children. This in-depth understanding will enable parents, educators, policy makers and government at all levels to give cognizance to nutritional issues and interventions, and also create appropriate population-based dietary policies for infant and child nutrition.

Early childhood nutrition programmes as a way to raise living standards in developing countries have been increasingly promoted by policy makers (World Bank 1993).Such programmes have been argued to improve diet in the crucial first years of life, enhances intellectual development and, ultimately, academic success (Brown and Pollitt 1996).

Issues in Healthy nutrition and Malnutrition

An integral component of daily life that contributes to the neurological, physical, mental, emotional and social well-being of individuals is said to be healthy nutrition. It encompasses having access to micronutrient-rich food; safe water; proper health care; and good hygiene practices. Nutrition is influenced by three broad factors: food, health and care (UNICEF, 2013). Nutritional well-being is determined by consuming safe food as part of an appropriate and balanced diet that contains adequate amounts of nutrients in relation to bodily requirements (WHO, 1998). Good nutrition during childhood lays the foundation for a healthy individual at later years of life. School-aged children grow rapidly; hence, it is of necessity to make provision for the needed diet at this stage of development. Good nutrition is the first line of defence against numerous childhood diseases, which can leave indelible mark on a child for life.

Begum and Nessa (2008) defined malnutrition as a pathological state resulting from a relative or absolute deficiency or excess of one or more essential nutrients, it is one of the

principle public health problems affecting large sections of populations especially children in developing countries. In a study carried out by Benítez-Bribiesca(1999) on 13 severely undernourished infants, compared to seven adequately fed babies fewer numbers of neurons with shorter dendrites and abnormal dendritic spines in individuals with malnutrition was found. Malnourished children have less energy and interest for learning that negatively influences cognitive development (Engle, 2010). Malnutrition could lead to decreased attention, deficient learning, and lower educational achievement.

Cognition and Cognitive Functions

Cognition represents a complex set of higher mental functions sub-served by the brain, and includes attention, memory, thinking, learning, and perception (Bhatnagar and Taneja, 2001). Attention and memory are two major cognitive functions in school-aged children. Attention is the processes through which sensory focus is directed toward external stimuli. This include, maintaining alertness and orienting toward compelling external stimuli. Attention is commonly considered to be a unitary construct (Engle, 2010). It allows children to accrue important information about their surroundings and to engage in the dynamic social interactions that form the basis for interpersonal relationships as well as the ability to monitor a stimulus stream for the occurrence of a specific target.

Memory implies the encoding, storage, and retrieval of information. From a developmental perspective, the capacity to hold information and process it supports various higher level accomplishments such as language, categorization, and social cognition. Memory is of two types namely; explicit and implicit memory. Explicit memory is also known as declarative memory which refers to the ability to remember unique events, facts, and people and depends on the integrity of the hippocampus and surrounding cortical areas, which are collectively called the medial temporal lobe (Sakai, 2005). Implicit memory accumulates more slowly as the result of repetition, as in the acquisition of the motor skills necessary to play a musical instrument or drive a car, and which has been related to the functions of the basal ganglia structures situated in the dorsal striatum (Neville and Bavelier,2002). Working memory refers to the ability to hold information “on line,” use it to accomplish a goal, and then discard it. Working memory has been linked to development of prefrontal cortex. The capacity to hold information in working memory emerges during the

first year and working memory capacity continues to improve during childhood (Reznick, Morrow, Goldman and Snyder, 2004). Other cognitive abilities in school-aged children include; categorization, problem-solving and counting.

Development of memory in children most especially declarative memory is very rapid throughout the first two years of life. This cognitive development is evident in increased attention, language acquisition, and increasing knowledge. There is a difference in the brain development of explicit and implicit memory in infants. Implicit memory is developed through maturation of striatum, cerebellum, and brain stem which are all involved in implicit learning. Explicit memory development depends heavily on structures in the medial temporal lobe, including the hippocampus and the parahippocampal cortex.

Recall in memory(otherwise called memory call) is regarded as the mental process of retrieving information from what was stored in the past. It is one of the three core processes of memory including encoding and storage. There are three main types of recall namely: free recall, cued recall and serial recall. Free recall describes the process in which a person is given a list of items to remember and then is tested by being asked to recall them in any order (Bower and Gordon, 2000). Free recall often displays evidence of primacy and recency effects. Primacy effects are displayed when the child recalls items presented at the beginning of the list earlier and more often. The recency effect is when the child recalls items presented at the end of the list earlier and more often (Bower and Gordon, 2000). Cued Recall is when a child is given a list of items to remember and is then tested with cues to remember material. The presentation could either be visual or auditory. Serial recall is the ability to recall items or events in the order in which they occurred (Henson, 1996). Serial-order also helps a child to remember the order of events in lives, for instance, autobiographical memories.

Influence of Nutrition on Brain function

All human developmental processes are disposed to the influence and interplay of biological and environmental factors. According to Giedd, Stockman, Weddle, Liverpool, Alexander-Bloch, Wallace (2010), brain development follows a genetic programme which is influenced by environmental factors including nutrition. Hsu, Lee and Chiu (2007) assert that during embryonic, fetal and early postnatal life, genetic determinants specify the fate of

neuronal progenitors and their migration to brain regions. Heng, Moonen and Nguyen(2007) submitted that these genetic determinants also modulate synaptic signal transmission and contribute to the establishment and maintenance of the central nervous system. Environmental influences may modify gene expression through epigenetic mechanisms, whereby gene function is altered through the processes of DNA methylation, histone modification and the modulating effect of non-coding RNAs, without the alteration of the gene sequence per se(Jacobson, Jacobson and Muckle, 2008). Nutrition is a nurturing (environmental) factor which can directly modify gene structure and mediate the expression of genetic factors by providing the specific molecules that enable genes to exert their potential on brain growth and development. The brain is a specialized tissue in which functionality depends upon the generation of electrical potentials and their conduction through long axonal components of cell-bodies and through the synaptic gaps between these cell-bodies. Nutrients which include choline, folic acid, iron, zinc and special fats such as gangliosides, sphingolipids and docosahexaenoic acid (DHA) are important for synaptogenesis particularly for brain growth (Jacobson, Jacobson and Muckle, 2008) and retinoic acid, the active form of vitamin A, is involved in central nervous system morphogenesis and patterning (Parada, Gato and Bueno, 2008).

Levitt (2003) noted that environmental(nurturing) factors play an equally critical role in shaping the neural configuration through postnatal synaptic “blooming and pruning” that incorporates ongoing experiences into the developing synaptic architecture of the brain. Environmental factors act by modifying gene expression through epigenetic mechanisms (Zeisel, 2009). The epigenetic effect of nutrients was exerted by altering histone acetylation, and the effects of hypoglycemic diets on the genetic expression of neuronal factors (Levi and Sanderson, 2004). Neuron is one of the cells that constitute nervous tissue which transmit and receive nervous impulses; axon is a long projection of the neuron that conducts nerve impulses away from the nerve cell body; dendrite is a branching projection of the neuron that conducts nerve impulses toward the nerve cell body; synapse is the place between nerve cells through which nerve impulses pass from one neuron to another and Myelin is a soft white material of lipid and protein that covers axons to insulate and accelerate nerve impulse.

Good nutrition are required for the creation of new neurons, for the growth of axons and dendrites, for the formation of synapses, and the covering of axons with myelin, which is

fatty matter that accelerates the speed of nerve impulses traveling from one cell to another. Some nutrients facilitate the incorporation of experiences into cognitive functions by being the basic structural components of neuronal cell-bodies and synapses (Zeisel, 2009). Nutrient plays a critical role at the cross-roads of the biological and nurturing factors that mediate brain growth and development such as cell proliferation, DNA synthesis, and production of key neurotransmitters such as acetylcholine, dopamine, and serotonin, hormone metabolism, maintenance of brain tissue and are important constituents of enzyme systems in the brain. Hence, each child is born with the intrinsic capacity to learn, but how and what the child learns could be determined by the environment.

Nutrition in school-aged children

It has been recommended by nutritionists that children should eat five times in each day. Children should be provided with food that will give an adequate amount of energy such as fats, carbohydrates, vitamins, minerals and proteins. Proteins help to build human cells and sources are animal liver, lean red meat, fish, chicken, turkey, seafood, cheese, milk and eggs and some products derived from soybeans, green beans, dairy foods, peanut butter, soya products, nuts, seeds, wheat and legumes. The Institute of Medicine in 2012 recommends that children ages 4 to 8 need at least 19 grams of protein, ages 9 to 13 require 34 grams of protein, teen girls ages 14 to 18 need 46 grams and teen boys ages 14 to 18 require at least 52 grams of protein every day.

Fat is essential for balanced energy level in children. According to The Institute of Medicine (2012), school-age children ages 4 and older should consume 25 to 35 percent of their daily calorie intake from fats, especially mono- and polyunsaturated fats found in vegetable oils, avocados, peanut butter, hummus, nuts and seeds. Erickson (2006) opines that fat makes up more than 60% of the brain and acts as a messenger in partial control of aspects such as mood. Foods rich in omega-3 fatty acids include purified fish oils, canola oil, walnut oil, walnuts, soybeans, soybean oil, algal oil, flaxseeds, flaxseed oil and pumpkin seeds. Omega-3 fatty acids such as those found in salmon, kiwi fruit, and walnuts, provide many benefits in improving memory and learning, much of which occurs at the synapses. Omega-3 fatty acids support synaptic plasticity and seem to positively affect the expression of several molecules related to learning and memory that are found on the synapses.

Carbohydrates which are the most important source of energy for the body during childhood could be derived from sugars, starches and fiber. It provides energy to all tissues in the human body, especially the brain and red blood cells which normally utilize glucose as the fuel for cell activity. The Institute of Medicine (2012) suggests that all children ages 1 and older should consume at least 130 grams of carbohydrates every day. Carbohydrates from whole grains, milk products, fruits, vegetables and legumes increase the nutrition of children's diet. Refined grains and added sugar food should be avoided.

Vitamins are essential and vital in a proper diet for small children. Vitamin A is necessary for correct development of vision, to guarantee the integrity of epithelial tissue and development of tissue differentiation. The main sources of vitamin A are: liver, dairy products, eggs, fish, margarine, fruits and vegetables. Vitamins B help in the growth, sustenance and development of children. Vitamin C is essential for optimum functioning of the immune system and collagen synthesis. It contains antioxidant properties and plays a significant support role in the process of iron absorption. Vitamin D in fish, dairy products and iodine obtain from seafood, dairy products, enriched grains and iodized salt plays an essential role in metabolizing muscle functioning, cell proliferation and maturation and correct functioning of the immune system. Vital nutrients for school-age children include calcium found in dairy products and dairy-free calcium-fortified beverages, iron in meats and iron-fortified grains.

Minerals in diet are good for children, most especially iron, calcium, magnesium, phosphorus, sodium, zinc and iodine. Manganese and magnesium are two minerals essential for brain functioning; sodium, potassium and calcium play a role in message transmission and the thinking process. Erickson (2006) opine that vitamins and minerals as an important substance for the functioning of the brain. Most important are the vitamins A, C, E, and B complex vitamins.

According to The U.S. Department of Agriculture(2008), girls aged 4 to 8 need 1,200 to 1,800 calories, girls aged 9 to 13 require 1,400 to 2,200 calories and teen girls aged 14 to 18 need about 1,800 to 2,400 calories each day. Boys aged 4 to 8 require 1,200 to 2,000 calories, boys aged 9 to 13 need 1,600 to 2,600 and teen boys aged 14 to 18 need about 2,000 to 3,200 calories per day to maintain a healthy body weight. The National Nutrition Standards (2000) submitted that meals must provide one third of the RDA of protein, vitamin A,

vitamin C, iron, calcium, and calories. No more than 30% of the meals calories should be from fat and fewer than 10% of the calories should come from saturated fat. The following dietary guidelines are recommended for children and adolescents by the National Nutrition Standards, which was published by the School Nutrition Association (2000):

1) One to two ounces of meat/meat alternative daily;
2) 10-14 serving of grains/bread per week;
3) One half cup fruit daily;
4) One half cup vegetables daily;
5) 8 ounces of milk and dairy products daily;
6) Grains (bread and pasta) daily;
7) Fish: At least three times per week;
8) Cheese: Twice a week;
9) Eggs: Once or twice a week;
10) Legumes: At least twice a week

Impact of Nutrition on Cognitive development and Education

Existing research makes a convincing case that nutrition and health interventions will improve school performance (WHO, 1992). Good health and nutrition are needed for concentration, regular school attendance and optimum class performance (Levinger, 1996). Kleinman and Green (2002) carried out a research study on the implementation of a universal breakfast program on the academic performance of school-aged children and found that children who participated in the program have improved nutrition status. Those children with improved nutrition status experienced decreased hunger, reduced absenteeism, and increased math scores. Taras (2005) found that schools which had a breakfast program not only had lower tardiness and absentee rates, but positive effects on brain function and higher scholastic scores as well. Verbal fluency, arithmetic, attention tests, memory, creativity, endurance, and general cognitive functioning were found to be a result of eating nutritious food

According to Chugani (1998), Children's brains use more glucose than adult brain. Eating breakfast replenish blood glucose levels that a child's brain needs to perform well academically. Thus, regular breakfasts improves brain function by providing the necessary level of glucose. In a cross-sectional study done in China, Liu , Hwang , Dickerman , Compher (2013) found that kindergarten students who ate breakfast had higher IQs than who ate breakfast sometimes or rarely, and this persisted even after controlling for factors such as parental education and current living situation. Also, children who eat breakfast regularly with their parents experience improved communication. It is likely that vocabulary and comprehension skills improve as a result of regular family meals. In Norwegian, among the 475 high school students surveyed by Overby , Lüdemann and Høigaard (2013) , those who ate breakfast regularly had a reduced risk of writing, reading, and mathematical learning difficulties.

S0 (2012) conducted a large study in Korea which examined breakfast consumption among 75,000 students in grades 7 to 12. Male students who ate breakfast five days per week experienced improved academic performance compared with those who didn't eat breakfast. Among female students, positive associations were seen with as few as two breakfasts per week. With both sexes, eating breakfast every day showed improved academic performance. Another research done by Kim, Frongillo and Han (2003) in Korea found that children who ate breakfast regularly had grade point averages that were 0.15 to 0.28 points higher compared with those who didn't eat breakfast regularly. In a similar research carried out by Asbridge, Florence, and Veugelers (2008), found that students who eat breakfast had higher cognitive functioning than those who skipped it.

In their research, Lahey and Rosen (2010) found that about one-third of children who completed a food-habit questionnaire had inadequate fruit and vegetable intake. These students also showed poor school performance as compared to those students who had an adequate intake of fruits and vegetables. The study concluded that nutrition affects learning and behaviour and suggested that diet can influence cognition and behavior in many ways, which include the condition of not enough nutrition or the condition of the lack of certain nutrients. Another study by Li & O'Connell (2012) discovered that 5th grade students who ate more fast food got worse scores on math and reading. Edwards , Mauch and Winkelman (2011) found that higher mean math standardized test scores were associated with students

who ate nutritious food more frequently among 800 sixth-grade students in North Dakota's Fargo Public Schools, in the United States.

A study done by Paramji and Sharma (2007) using sixty girls of 7-9 years belonging to low socio-economic group in Ludhiana city found that the intake of all nutritious food (protein, calcium, ß carotene and Vitamin C) increased significantly in the experimental group after nutritional counselling . Hematological profile and IQ scores significantly increased and percentage of girls in high intellectual score category increased from 23.3 to 43.3. This may be due to increased food intake and also due to adoption of desirable nutritional practices.

In a survey research, Dodsworth (2010) recruited 1,194 students aged 7 to 12 in an eighth grade class for 14 class days. Participants completed questionnaires each day about nutritional choices and the instructor evaluated major areas of academic achievement daily. The areas of academic achievement that were examined include participation, attendance, work, and behaviour. A 5 point scale was developed to rank participants, nutrition for the day and achievement and provide for correlation between the two areas under investigation. Participants were given a questionnaire about their personal nutritional choices when they entered the science class each day, for 14 class days. The survey had six questions on it and was completed at the beginning of class each day for the duration of the study. The study found that those that take nutritious food had an average academic achievement score of 4.343 while others had an average academic achievement score of 3.800.

Conclusion

Improving children's health is very crucial in achieving improved academic performance. Since the progress of a nation depends on the health of its citizens, developments in the effort to enhance education and school performance should emphasize on improved health and the nutrition status of school-aged children. By doing this, the nation can boast of citizens with good health and sound mind, higher output including high and outstanding performance in school. Also, there is need for an enabling school environment through well-articulated policies, projects, and programmes /interventions to ensure wholesome development of Nigerian children and enhance their quality of life.

In this contemporary world, many parents because of job demands and daily hassles opt for fast foods for their children and wards. This excessive intake of total fat, saturated fat, and cholesterol contributes to health problems and poorer performance (Zhang, Hebert & Muldoon, 2005). There is an adage that says "You are what you eat". Good nutrition during the early years of life is important for growth support and maximizing learning potential. Good health and nutrition are needed for increased energy levels, mental clarity, emotional and well-functioning, concentration, regular school attendance and optimum school performance. However, poor nutrition often poses a serious barrier to equipping children with the necessary tools and skills for success.

Recommendations

1. Health and Physical education teachers are to lead the quest for the prevention of unhealthy students by developing nutrition curriculum which incorporates innovative themes that influence both health and academic performance.
2. Workshop could be organized on the developed nutrition curriculum for students, parents and teachers so as to help improve nutrition beliefs and behaviours. Such nutrition education programmes and counselling may be done in schools, through community organizations, or through a private practice.
3. Nutrition education needs to be included in every school curriculum as learning to know "What to eat and Why" is an essential aspect of child's education.
4. Teaching all children the meaning and importance of good nutrition will ameliorate the issues of nutrition illiteracy and misunderstandings.
5. Monthly nutrition posters should be placed on bulletin boards at schools and nutrition newsletters with sample menus and up-to-date nutrition.
6. Teachers should send information to families consistently so as to stimulate parental involvement and help mothers make good food choices for their children. Hence, this will improve nutritional status of children to the desired level.
7. Schools should establish committees that include parents and community members to promote a healthy school atmosphere by focusing on nutrition and vending policies.
8. School vendors should only sell foods and beverages that contribute to meeting the dietary needs of students and not for profits.

9. A policy of subsidizing the price of food could be adopted. Food subsidy will help children from low socio-economic status to have access to nutritious food at an affordable price.
10. Provision of lunch during school period should be made for all students to support nutritional needs of school children.
11. The school authority should ensure students are not starting the school day hungry as such school breakfast programs should also be made available.

References

Asbridge M., Florence M.D and Veugelers P.J (2008). Diet quality and academic performance. *Journal of School Health*, Vol;78(4):209-215.

Begum M. and Nessa Z. (2008). Nutritional status of school going children of a selected school of Dhaka City. Bangladesh. *J. Sci. Ind. Res*. Vol.43: 97-102.

Benítez-Bribiesca L., De La Rosa-Alvarez I., Mansilla-Olivares A. (1999).Dendritic spine pathology in infants with severe protein-calorie malnutrition. P*ediatric. Vol.* 104;21.

Bhatnagar S. and Taneja S. (2001). Zinc and cognitive development. *British. Journal of. Nutrition*. 85, S139–S145 10.1079/BJN2000306 .

Brown J.L and Pollitt E. (1996). Malnutrition, poverty and intellectual development. *Science America.* Vol.274:38–43.

Brown, J. L., Beardslee, W. H., and Prothrow-Stith, D. (2008). Impact of school breakfast on children's health and learning: An analysis of the scientific research. Retrieved from the SodexoFoundationwebsite:http://www.sodexofoundation.org/hunger_us/Images/Impact%20of%20School%20Breakfast%20Study_tcm150-212606.pdf

Center for Disease Control and Prevention (2012) National Center for Health Statistics. *CDC growth charts*. Retrieved from www.cdc.gov/growthcharts/

Center for Disease Control.(2013). *Childhood obesity facts*. Retrieved from hhttp://www.cdc.gov/healthyyouth/obesity/facts.htm

Chugani H.T.(1998). A critical period of brain development: studies of cerebral glucose utilization with PET. *Prev Med*. Vol. 27(2):184-188.

Dodsworth, L. M.(2010). "Student Nutrition and Academic Achievement" .*Mathematical and Computing Sciences Masters.* Paper 96.

Edwards J.U, Mauch L. and Winkelman M.R (2011). Relationship of nutrition and physical activity behaviors and fitness measures to academic performance for sixth graders in a midwest city school district. *Journal of School Health Vol; 81*(2):65-73.

Erikson, J. (2006). Brain food: the real dish on nutrition and brain function. *WisKids Journal*, Novemeber/December.Geneva.

Gordon H. (2000). A Brief History of Memory Research. The Oxford Handbook of Memory.USA

Giedd J., Stockman M., Weddle C., Liverpool M., Alexander A. and Wallace(2010).Anatomic magnetic resonance imaging of the developing child and adolescent brain and effects of genetic variation. *Neuropsychol. Rev*. 20, 349–361 10.1007/s11065-010-9151-9

Jacobson J. L., Jacobson S. W. and Muckle G., (2008). Beneficial effects of a polyunsaturated fatty acid on infant development: evidence from the Inuit of Arctic Quebec. *Journal of Pediatric*. 152, 356–364, e351. 10.1016/j.jpeds.2007.07.008

Heng J.I, Moonen G. and Nguyen L.(2007). Neurotransmitters regulate cell migration in the telencephalon. *Eur J Neurosci*.Vol.26:537–46.

Henson, R. (1996). Short-term memory for serial order. Dissertation for PhD of Philosophy. St. John's College, University of Cambridge Bower.

Hsu Y.C, Lee D.C and Chiu I.M.(2007). Neural stem cells, neural progenitors, and neurotrophic factors. *Cell Transplant.*Vol.16:133–50.

Jacobson J.L, Jacobson S.W and Muckle G. (2008). Beneficial effects of a polyunsaturated fatty acid on infant development:. *Journal of Pediatric.* Vol.152:356–64.

Kim H.Y, Frongillo E.A and Han S.S (2003) . Academic performance of Korean children is associated with dietary behaviours and physical status. *Asia Pacific Journal of Clinical Nutrition.* Vol;12(2):186-192.

Kleinman, R. E., Hall, S., Green, H., Korzec-Ramirez, D., Patton, K., Pagano, M. E., and Murphy, J. M. (2002). Diet, breakfast and academic performance in children. *Annals of Nutritional Metabolism, 46*(Suppl 1), 24-30.

Kreb-Smith S., Guenther P., Subar A., Kirkpatrick S. and Dodd K.(2010). Americans do not meet federal dietary recommendations. *Journal of Nutrition;* 140(10):1832-1838.

Lahey, M. and Rosen, S. (2010). Dietary factors affection learning behavior. Retrieved from http://childrensdisabilities.info

Levi R. S and Sanderson R.(2004).Dietaryregulationofgeneexpression.*Curr.Opin.Gastroenterol.* Vol.20, 139–142

Levinger, Beryl. Nutrition, Health and Education for All. Newton, MA: Education Development Center, 1996.

Levitt P. (2003). Structural and functional maturation of the developing primate brain. *Journal of Pediatric*. Vol.143, 35–45 10.1067/S0022-3476(03)00400-1

Li, J.and O'Connell, A. A. (2012). Obesity, high-calorie food intake, and academic achievement trends among U.S. school children. *The Journal of Educational Research, 105*(6), 391-403

Lieberman, H. (2003). Nutrition, brain function, and cognitive performance. *Appetite,* 40, 245–254

Liu J., Hwang W.T, Dickerman B, Compher C.(2013). Regular breakfast consumption is associated with increased IQ in kindergarten children. *Early Human Development*. Vol; 89 (4):257-262.

Neville H, Bavelier D. Human brain plasticity: evidence from sensory deprivation and altered language experience. *Prog Brain Res*. 2002;138:177–88.

Ogannah (2015) The role of nutrition in children's neurocognitive development, from pregnancy through childhood. *Front Hum Neurosci*. 2013;7:97**.**

Overby N.C, Lüdemann E. and Høigaard R.(2013). Self-reported learning difficulties and dietary intake in Norwegian adolescents. *Scand Journal of Public Health*. Vol. 41(7):754-760.

Parada C, Gato A and Bueno D.(2008). All-trans retinol and retinol-binding protein from embryonic cerebrospinal fluid exhibit dynamic behaviour during early central nervous system development. *Neuroreport*.Vol.19:945–50.

Paramjit K.C and Sharma .S. (2007). Nutritional Status and Mental Ability of School Girls (7-9 years) as Influenced by Nutrition Counselling *Journal of Human Ecology*. Vol.12 165-169.

Pollit E, Watkins W.E and Husaini M.A. 1997. Three month nutritional supplementation in Indonesia infants and toddlers, benefit child memory function 8years later. *American. Journal of Clinical. Nutrition.* Vol.66: 1357-1363.

Pollitt P. and Matthews R. 1998. Breakfast and cognition: An integrative summary. American *Journal of Clinical Nutrition*. Vol.67(suppl 1):804-813.

Reznick J.S, Morrow J.D, Goldman B.D and Snyder J. (2004). The onset of working memory in infants. *Infancy.* Vol;6:145–54.

Reznick J.S, Morrow J.D, Goldman B.D and Snyder J.(2004). The onset of working memory in infants.*Infancy*. Vol;6:145–54.

Sakai K.L (2005). Language acquisition and brain development. *Science.* Vol..310:815–9.

School Nutrition Association (2000). Dietary Reference Intakes. Washington, D.C: National Academy Press.

So, W.Y (2013). Association between frequency of breakfast consumption and academic performance in healthy Korean adolescents. *Iran Journal of Public Health*. Vol;42(1):25-32.

Taras, H. (2005). Nutrition and student performance at school. *Journal of School Health, 75*(6), 199-213.

The Institute of Medicine (2012) Dietary guidelines for Americans 2012 (Publication No. HHS-ODPHP-2012-01-DGA-A). Retrieved from The Institute of Medicine :http://www.health.gov/DietaryGuidelines/dga2005/document/default.htm

The US Department of Agriculture (2008). MyPlate: vegetables — health benefits and nutrients. website. http://www.choosemyplate.gov/food-groups/vegetables-why.ht

UNICEF, (2013). *Inequalities in Early Childhood Development: What the data say-Evidence from the Multiple Indicator Cluster Surveys.* New York: UNICEF

WHO, (1992). Comprehensive School Health Education: Suggested Guidelines for Action.

World Bank. (1993). Worldwide Prevalence of Anaemia 1993: WHO Global Database on Anaemia, Geneva

Zeisel S. H. (2009). Importance of methyl donors during reproduction. *American. Journal of Clinical. Nutrition. Vol.*89, 673S–677S 10.3945/ajcn.2008.26811D

Zhang, J., Hebert, J. and Muldoon, M. (2005). Dietary fat intake is associated with psychosocial and cognitive functioning of school-aged children in the united states. *The Journal of Nutrition*, 135, 1967-1973.

View publication stats