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Improving Cognitive Functioning through Nutritional Intervention Program: A study on School going Children

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ABSTRACT--*Food is an integral part of our lifestyle and it has been realized that food affects all aspects of our being. It has also been a topic of research that food affects our cognitive functioning. The current study aimed to recognize nutritional deficiencies in children from the age 8-11 years. 141 children deficient in vitamin B12, iron, folic acid and vitamin D were identified on the basis of a blood test and were included in the study. Baseline measures of cognitive functioning were established on Malin's Intelligence Scale for Indian Children (MISIC; Malin, 1969). Random assignment of 91 subjects was done to the experimental group and the remaining 50 subjects were observed as controls. The experimental group was given an intervention plan which consisted of a diet plan under the guidance of a nutritionist, micro-nutrient supplements under the guidance of a paediatrician and awareness regarding healthy food habits by the researcher. After 45 days of intervention post test scores were obtained. There was a significant improvement in the cognitive functioning of children in the experimental group. The post test scores of the experimental group were also significantly higher than the post test scores of the control group. The findings of the study confirmed the role of nutrition in the cognitive development of children.*

Key Words-- *Cognitive functioning, nutrition, micro-nutrients*

I. INTRODUCTION

In a culture like ours food occupies a very important place. Besides being a vital element of our social and psychological environment food gives us nutrition. Nutrition refers to the nourishment obtained from food consumed. Nutrition encompasses social, economic, cultural and psychological implications of food and eating. Nutrition plays an important role in the health of an individual. Health refers to the level of social functional and metabolic efficiency of an organism. Thus, health is a bio-psychosocial phenomena and the holistic approach to health promotion and protection is the integration of these perspectives.

The nutritional status of school children is an important indicator of the health of a community. A survey carried out in nine states of India by National Nutrition Monitoring Bureau (NNMB) in 2000, shows that mean energy consumption, as percentage of recommended dietary allowances (RDA) is the least among school children, in spite of the fact that their requirement is the lowest. School age is the most active span of human life (Santrock, 1997). One of the most important factors influencing school child's development is nutrition. Various studies done in past

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had reflected that nutrition has had a positive impact on the survival, growth and development of young children. (Engle and Zeitlin 1996).

Nutrition has a considerable influence on human's health, not only in physical terms, but also mental and cognitive. Many researchers have reported the impact of nutrition on brain functioning (Growden and Wurtman,1980; Colby-Morley, 1981; Kretsch et al. 2001). The concentration of amino acids and choline (in the blood) help the brain in the creation and utilisation of many of its neurotransmitters such as serotonin, acetylcholine, dopamine and norepinephrine. Correct amounts of micronutrients in the food are important for the brain to make the right amount of amino acids and choline.

Dietary components are important for brain function and neurotransmitter activity (Wolfe & Burkman, 2000) and the most important recommended nutrients known today are protein, fat, B vitamins, iron, chlorine and antioxidants. Offering students, the right food choices and helping them develop positive, healthy eating habits will support optimal functioning of the brain.

Research also shows a correlation between malnutrition and cognitive impairment. Kar, Rao and Chandramouli (2008) reported that malnutrition causes stunted growth and a general slowing down of the rate of development of all cognitive processes. Brain consumes an immense amount of energy as compared to other body parts. The brain functions are controlled by the neurons which are influenced by the food in many ways. The processes managing the neurons can affect synaptic plasticity which further affects cognitive functioning (Vaynman, Ying, Wu & Gomez-Pinilla, 2006). In Yates et al (2018) study it was observed that early deficiencies of Vitamin D concluded in learning and memory problems. Vitamin D plays a vital role during the early stages of life. In a study by Stessman & Peeples (2018), it was seen that babies born with Vitamin D deficiencies were more prone to brain injuries. A study by Gezen et al. (2014) shows that Vitamin D is actually responsible for release of the nerve growth factor (NGF) which is important for the survival of hippocampal neurons.

There is no dearth of literature to show that certain micronutrients play a vital role in cognitive functioning. As a result interventions based on dietary changes and micronutrient supplements are becoming popular with many psychiatric conditions, specially related to degenerative disorders (Sacks,2004; Wu,Ying, Gomez-Pinilla, 2008). Many such interventions have shown promising results with children. Children aged 6-12 years were given supplements of Omega 3 fatty acids and micronutrients such as iron, folate, vitamin B12, vitamin A, D and C showed higher scores in verbal intelligence, learning and memory in the children (Osendarp, Baghurst, Bryan, Calvaresi, Huges, Hussaini, Karyadi, Klinken, Knaap, Lukito, Mikarsa, Transier & Wilson, 2007).

II. CURRENT RESEARCH

Micronutrient deficiency can have long term impact on cognitive functioning of children. This is particularly relevant to Indian children as the rates of malnutrition are very high in a developing country like India. Many studies have been conducted on Indian children and but most of them highlight the physical impacts of micronutrient deficiencies. Also there are very few studies which have studied multiple micronutrient deficiencies. And there are very few studies which have used a pre-post design to study the impact of micronutrient supplements on cognitive functioning of school going children. The current study is an attempt to fill this gap and add to the current knowledge on nutritional deficiencies

OBJECTIVES

- To recognise nutritional deficiencies in children from the age 8-11 years
- To study the impact of child nutrition on cognition.

HYPOTHESES

H_1: The post-test scores of cognitive functioning in the intervention group will be significantly higher than the post-test scores of the control group.

H_2: The post-test scores of cognitive functioning will be significantly higher than that of pre-test scores in the intervention group.

H_3: There will be no difference in the pre-test and post-test scores of the control group.

SAMPLE OF THE STUDY

The study comprised a total of 141 students, studying between 3-5 grade in a private CBSE school. Only those students were selected whose academic performance ranged between 40%-60%. Teachers of the selected students also reported them to have normal concentration, class room conduct and academic conduct. In the present study a purposive sampling technique was used to select the sample.

III. MEASURES OF THE STUDY

Malin's Intelligence Scale for Indian Children (MISIC; Malin, 1966)

(MISIC), Weschler Intelligence Scale for Children was adapted and developed in 1966 to assess the cognitive abilities of the child. This is used for children aged 6 to 15 years. This battery comprises 11 sub-tests, **6 of which form the verbal scale and 5 on** the **performance scale**. In the current study 7 subtests were chosen according to the need of the research which was to analyze cognitive skills. As the test not only measures IQ, MISIC has been known to measure cognitive aspects such as memory, perception, visual motor coordination, attention etc. In the present study the sub tests were consciously chosen which would help in the analysis of cognitive functioning.

- **Block Design -** Children put red and white blocks together in a pattern according to a model displayed. Conceptual reasoning, spatial visualization and visual-motor coordination formation are involved. The subject has to use logic and logic to successfully complete the objects.
- **Digit Span -** Children are given the sequence of numbers in verbally and are asked to repeat them, either heard and in reverse order. Short term memory and meditation are measured through it.
- **Coding —** Children mark rows of figures with different rows according to a code, transfer more than 8 children to one digit-symbol code. Time is limited with bonuses for speed of work. Conceptual organization is also included.
- **Maze:** Children are presented with a series of designs with a missing part which needs to be completed. This sub-test measures analytical reasoning.
- **Picture Completion:** Each problem contains a picture having a part missing. One has to identify the missing part. This subtest measures performance in deliberately focusing attention.

- **Picture arrangement:** The examinee has to complete a story through series of pictures from left to right. It measures reasoning skills
- **Object assembly:** Children have to correctly assemble the puzzle. This subtest helps in measuring organizational, visual anticipation and motor problem solving skills.

Biochemical test

The biochemical tests encompassed Hemoglobin, Vitamin B12, Folic Acid, and Vitamin D. the tests were conducted on a blood sample at a pathological lab.

Demographic Questionnaire:

A basic demographic questionnaire about the child was formed and details were taken.

IV. DESIGN OF THE STUDY

Before and after experimental design was adopted with controls for the current study. Baseline measures were obtained at the beginning of the study. Random assignment of subjects was done to two groups. Both the groups were checked for significant differences in average baseline scores. Post test scores were obtained for both the groups after the intervention.

PROCEDURE

In phase I, parents of 347 children who had below average (40-60%) school performance were approached and were summarized about the whole process. Consent forms were given to them. 231 parents filled the consent form and agreed to be a part of the study. Children falling in exclusion category such as having hearing aids, having separated parents etc. were screened out. A total of 210 children were shortlisted for the study. The parents of 210 children got the required biochemical testing done from their desired biochemical laboratory. 141 children were diagnosed deficient in all i.e. B12, Iron, Folic acid and Vitamin D. Seven sub-test of MISIC were conducted on these children. 141 children were then divided into two groups randomly i.e. controlled and intervention group. Children in the experimental group were given a 45-day diet chart and medical supplements as prescribed by a paediatrician.

In phase II of the study days a post test of MISIC was taken of both the groups. Children in control group were not given any kind of nutritional intervention. The researchers maintained a continuous follow up to check that the experimental group was following the plan and that the control group did not opt for any changes in their nutrition during the course of the study.

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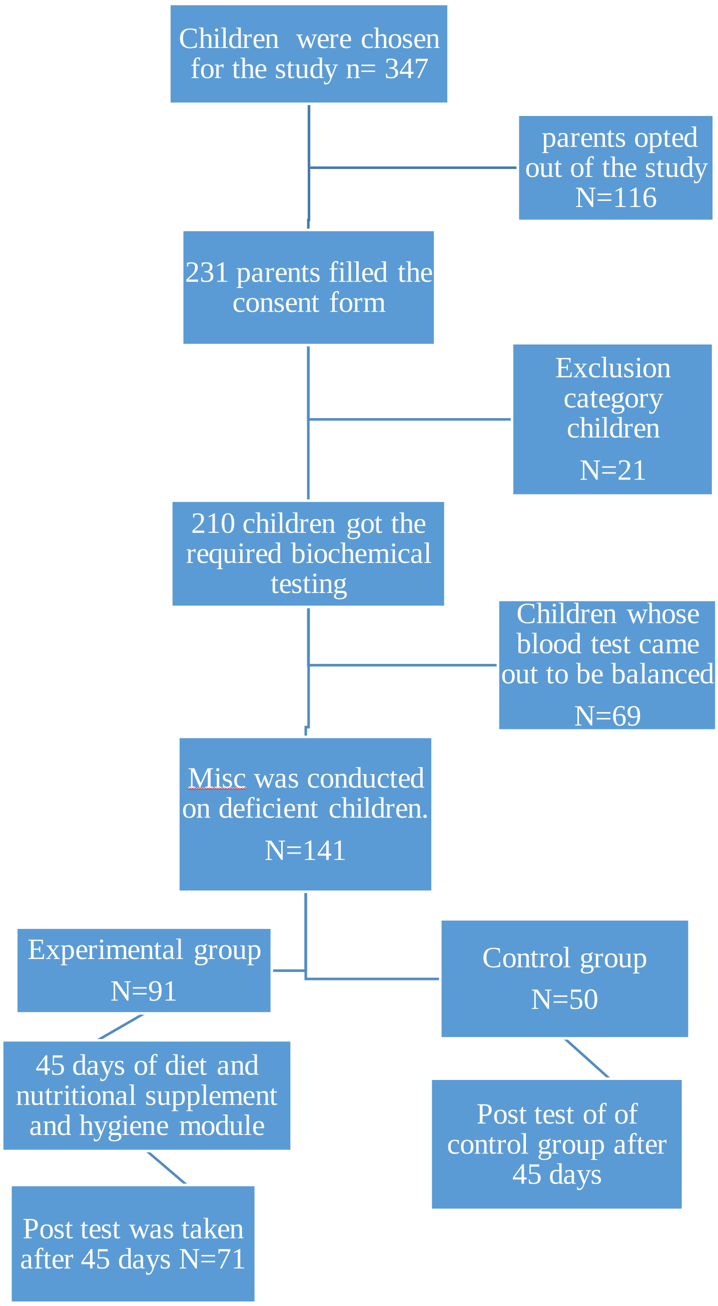

V. RESULTS

The current study was done with an aim of studying the impact of micronutrient supplement plan on the cognitive functioning of school children. The data obtained were processed in SPSS 21.

Table 1: Independent t test scores of Cognitive Functioning of Experimental vs Cognitive Functioning of Control on Pre-Intervention

Sub Test	Experimental Group		Control Group		
	Mean	**SD**	**Mean**	**SD**	**T**
Block Design	99.9	13.81	98.15	15.53	1.56 (NS)
Maze	90.3	14.56	89.7	13.67	.666 (NS)

Digit Span	88.05	8.19	96.95	12.93	1.23 (NS)
Coding	107.9	16.03	110.7	18.77	.768 (NS)
Picture Completion	95.1	16.56	95.5	14.23	.035 (NS)
Object assembly	92.6	14.22	92.8	13.87	.069 (NS)
Picture arrangement	85.5	13.05	84.9	12.58	1.37 (NS)

NS: Not Significant

Table 1 shows that the experimental and the control group did not differ significantly in their baseline scores of cognitive functioning.

Table 2: Independent t test scores Cognitive Functioning of Experimental Vs Cognitive Functioning of Control on Post-Intervention

Sub Test	Experimental Post-Intervention		Control Post-Intervention		
	Mean	SD	Mean	SD	T
Block Design	106.7	15.93	98.65	19.48	6.48**
Maze	105.3	16.56	90.32	14.29	7.98**
Digit Span	92.40	10.19	95.05	11.84	2.21*
Coding	109	14.54	111.25	14.26	2.28**
Picture Completion	111.1	14.75	97.04	13.38	5.56**
Object assembly	103.7	13.56	93.50	15.97	7.29**
Picture arrangement	100.2	12.47	86.01	13.53	10.56**

* Significant at .05 level

** Significant at .01 level

Table 2 shows a comparison between the cognitive functioning of experimental and control group after the intervention. The experimental group showed a significant improvement in cognitive functioning after the intervention.

Table 3: Dependent t test of Experimental Group to compare Cognitive Functioning scores before and after the Intervention

Sub Test	Experimental Group (PRE)		Experimental Group (POST)		
	Mean	SD	Mean	SD	T
Block Design	99.9	13.81	106.7	15.93	12.48**
Maze	90.3	14.56	105.3	16.56	9.56**
Digit Span	88.05	8.19	92.40	10.19	2.78**
Coding	107.9	16.03	109	14.54	2.31*
Picture Completion	95.1	16.56	111.1	14.75	7.96**
Object assembly	92.6	14.22	103.7	13.56	6.38**
Picture arrangement	85.5	13.05	100.2	12.47	6.93**

* Significant at .05 level

** Significant at .01 level

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Table 3 shows a comparison between cognitive functioning scores of the experimental group before and after the intervention plan. The results showed that the performance after the intervention was significantly better than before.

Table 4: Dependent t test scores of Control Groups on Cognitive Functioning Pre and Post Intervention

Sub Test	Control Group (PRE)		Control Group (POST)		
	Mean	**SD**	**Mean**	**SD**	**T**
Block Design	98.15	15.53	98.65	19.48	.86 (NS)
Maze	89.7	13.67	90.32	14.29	.58 (NS)
Digit Span	96.95	12.93	95.05	11.84	1.01 (NS)
Coding	110.7	18.77	111.25	14.26	.956 (NS)
Picture Completion	95.5	14.23	97.04	13.38	.756 (NS)
Object assembly	92.8	13.87	93.50	15.97	.840 (NS)
Picture arrangement	84.9	12.58	86.01	13.53	1.2 (NS)

NS: Not Significant

Table 4 shows the t-test results of comparison of cognitive functioning scores of the control group before and after the intervention. There was no difference in the two sets of scores.

VI. DISCUSSION

Results obtained from the current research confirmed the impact of micronutrients on cognitive functioning in school going children. The results provided support for hypotheses H1, H2 and H3.

The post-test cognitive functioning in the intervention group was higher than that of the control group (H1). As the control group wasn't given any intervention the scores didn't differ much than that of the pre-test. However, in the intervention group a significant difference was observed post-test as the group was given dietary modulations along with awareness sessions.

The post-test scores of cognitive functioning were significantly higher than that of pre-test scores in the intervention group (H2). The post-test scores of cognitive functioning were significantly higher than that of the pre-test. This signifies that the steps and interventions taken up by the researcher made a significant difference in the cognitive performances of the children suggesting the hypothesis to be correct.

There was no difference in the pre-test and post-test scores of the control group (H3). Since the control group did not receive any intervention during the course of the study, no difference was seen in the pre-test and the post-test scores of the control group.

The nutritional intervention had a significant impact on the cognitive functioning of the children. These results can be explained by the help of knowing how nutrients can influence neural plasticity, cell regeneration and energy metabolism. An important characteristic of the nervous system is neural plasticity, which allows the adaptation of a lifetime with the environment. Cognitive functions like learning, memory, attention etc. are dependent on synaptic plasticity. The nervous system modifies itself according to the experiences it has and the strength of neural plasticity allows new neural connections and acquire new knowledge. Nutrition is needed for the connection of the nerves, neurotransmitters, receptors etc., create new synapses or change the old ones. Fatty acids metabolize into the compounds which are part of the cell membrane, which is important for synaptic connections (Crawford & Sinclair, 1972). Functions of the hippocampus is dependent on synaptic plasticity which is responsible for cognitive functioning (Harvey & Pharmacol, 2007). In a study by Wu, Molteni, Ying & Gomez-Pinilla (2003) diets have actually been seen to have a direct effect on the neurons.

The process of restoration and renewal of cells is called cellular regeneration. For the existence and adaptation in the ever changing world it is an important survival process. Various nutrients in the food have shown connection with mitochondrial activity (Quinn et al., 2007).

At a growing age when the brain is developing along with other physical developments of the child it is only necessary that he/she follow a balanced diet and have a lifestyle which would nurture his/her development. Children require a fully balanced diet which has protein and minerals (Kahlor, Mackert, Junker, & Tyler,). In this changing world where packaged food seems more attractive and food portals seems more convenient the children need to learn to make the right choices in wide arrays of food options available to them to sustain a healthy life. Poor nutrition compromises the quality of life of children of the school-age group, but their ability to benefit from education (Patel, Gunjana, Patel, Thanvi, Sathvara & Joshi, 2015). Adequate nutrition in school going children are stepping stones to a healthy life.

School children grow at very fast rates, which means they need higher nutrition than ever before in their lifetime. In addition, the genetic background, sex, size and shape of the body are important determinants of all nutrient requirements. It has been shown through the study that malnutrition hampers the ability to think (Sandstead, 2000). Insufficient iron and zinc have been linked to the loss of neuropsychological tasks, slowing progress, decrease in immunity and increasing weakness to contagious diseases.

VII. CONCLUSION

This research highlights the role of micronutrients in the cognitive functioning of school children. The results have far reaching implications. School achievement is closely related to the cognitive functioning. If cognitive functioning can be improved through providing supplements, it might also help to improve school performance. In a developing country, micronutrient deficiency is a huge problem owing to the rates of malnutrition in children. But lack of knowledge regarding the role of dietary interventions also causes these deficiencies. The results of the current research will motivate parents to improve and regulate the dietary intake of children.

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