A study of iron and zinc deficiency on short term memory in children & effect of their supplementation

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ABSTRACT :

Background-: To identify the role of Iron & Zinc & their combined deficiency on Short term memory and to assess the response of supplementation therapy in the deficient children in the age group 6 – 11 years.

Methods-: In this interventional study 101 children were included from age group of 6-11 years (subdivided into 6-8 yr and 9-11 yr groups) from two different government schools. After collection of demographic data, the study children underwent hemoglobin, Serum Iron, Serum Total Iron Binding Capacity and Serum Zinc estimation. Verbal, Non-Verbal memory & Concentration assessment was done in all the children. Iron (2mg/kg/day BD) and zinc (5mg OD) supplemented for a period of 3 months for children in the deficient group.

Results-: All children with iron and zinc deficiency in both the age groups had memory & concentration deficits.

Conclusion-: Iron and zinc deficiency is associated with memory deficits in children. There is a marked improvement in memory & concentration after supplementation.

Keywords: Iron, Zinc, memory, concentration, Children.

INTRODUCTION:

Micronutrient deficiencies are widespread in many developing countries and are common among young person's hailing from low socioeconomic groups. Iron and Zinc are essential nutrient not only for the normal growth, health, and survival of children but also for their normal mental and motor development and cognitive functioning. Deficiency is associated with significantly poorer performance on psychomotor and mental development scales and behavioral ratings in infants, lower scores on cognitive function tests and lower educational achievement tests in preschool and school age children [1].

There are scanty data available regarding behavioral & cognitive changes occurring due to Fe or Zn or combined deficiency & no such study done in Western Rajasthan. So, this study was undertaken with the objective of identifying the role of Iron, Zinc and Combined deficiency(Fe & Zn) on verbal and nonverbal spheres of memory , and to find out the difference in affectation of various spheres of memory in deficient children & assess the response of supplementation therapy in the deficient children.

MATERIAL & METHODS:

This study was a cross-sectional, community based, interventional study. It was conducted during the period from December 2011 to December 2012 at the Kendriya Vidyalaya No.1, and Goverment Primary school by the Department of Pediatrics, Dr. S. N. Medical college, Jodhpur. Permission was obtained from the Assistant commissioner, Regional Office, Jaipur; and Principals of Kendriya Vidyalaya No.1 & Goverment Primary school . This study was approved by the college Ethical Committee. Written informed consent was taken from the parents of children who participated in the study.

Randomly selected children of both sexes in the age group of 6 to 11 years were enrolled for the study and subjected to memory assessment and hematological tests. Children with infection, fever, history of drug intake for any illness and girls who had attained menarche were excluded. Body weight of children without shoes (by bathroom scale with weighed to the nearest 100g) and height of children standing erect without shoes on the stadiometer were taken.

General physical and systemic examination was done to find out any abnormal finding in any system. They were grouped into 6-8 years (Group A; n=34) and 9-11 years (Group B; n=67). Further sub grouping was done based on levels of Iron and Zinc. hemoglobin estimation is done

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by Automated hematology analyzer analyzer, Serum Iron and Serum Total Iron Binding Capacity (TIBC) by colorimetric method, and Serum Zinc by Atomic absorption spectrophotometry. Based on Serum Iron levels, Total Iron Binding Capacity (TIBC) and Serum Zinc levels, Group A (6-8 years; n=34) and Group B (9-11 years ; n=67) categorized into 4 sub-groups:

Group 1: Iron deficient serum iron <60 meq/dL, TIBC > 360 and serum zinc >65 mcg/ dL) and

Group 2: Zinc deficient (serum iron > 60 mcg/dL, TIBC < 360 and serum zinc <65 mcg/dL).

Group 3: Combined deficient: Those with values suggestive of iron and zinc deficiency,

Group 4: Normal: Children with normal values of Iron & Zinc**.**

TESTS FOR MEMORY & CONCENTRATION

The tests were administered to each child in a quiet room. The environment was comfortable and free of distraction. Instructions were given to the children according to a pre-prepared standard protocol. Five tests were selected, which were generated from different sources [2], including Wechsler memory scale, Mini mental state examination, Binet-Kamath scale and Cattel's retentivity test, as described below.

(1) Digit span: This test is taken from Wechsler Intelligence scale for Children – Revised (WISC-R). This comprises of span for digit forward and backward. The subject was required to repeat a series of numbers called by the researcher and the difficulty level increased after each successful answer. Each correct answer was given a score, which was summed for the final score. The maximum number of digits used in the series is limited to 9. This test is a measure of attention , short term memory and auditory sequencing.

a. Digit forward: The subject is instructed to recite digit sequences of increasing length in the order presented.

b. Digit backward: The subject is instructed to recite digit sequences of increasing length in the reverse order.

(2)Vocabulary test: This subtest includes 10 unfamiliar words given to the subjects and instructed to recall them. This test is a measure of verbal memory.

(3) Benton visual retention test: This test is designed to assess visual perception, visual memory and visual-constructive abilities. There are 10 cards. Each card is exposed for 10 seconds and the child is asked to reproduce the design from memory. This test measures the visual spatial perception, visual and verbal conceptualization and immediate memory span.

(4)Cattell's retentivity test: It consists of complex and unfamiliar designs of irregular geometric figures which cannot elicit any verbal associations. On a card 10 geometrical figures are presented for 30 seconds, after a 2 minute pause and from the second card the child has to recognize the geometrical figures which he has already seen in the first card. This measures the visual recall for irregular geometrical designs and delayed memory span.

(5)Letter cancellation test: This test is a measure of concentration .The children are given the test which has many alphabets typed out in rows and the children are instructed to score out the A's and E's within a period of 2 minutes. If the child has omitted to score a letter or if he/she has scored a letter which is not A or E, it is considered as a wrong. If the child has correctly struck out an A or E it is considered as right. The final score is obtained by subtracting the total of wrongs from the totals of rights.

Deficient children were given the Iron/Zinc supplements depending on the element in which they are deficient: Syp Iron (ferrous ascorbate) - 2 mg/kg/day, Zinc - 5 mg once-a-day in the form of syrup given for 3 months. Children who were deficient in both the minerals were also given both Fe & Zn for a period of 3 months. The normal children were advised nutritious food during the study period & no intervention was done. All memory tests will be repeated after three months supplementation of required minerals. Due to drop outs, only 101 students continued in the study.

Statistical Methods:

The Data was analyzed with the help of Microsoft Excel 2007, statistical software "STAT PACK version 3.0" .The statistical analysis was performed by using student's "t" test and Chi squire test to find out the significance of difference in mean between two variables. One way ANOVA (Analysis of Variance: Single Factor) was done to compare the effects of the nutritional intervention and improvement in memory score in different spheres after supplementation between groups. Continuous data of sample were summarized as mean ± SD and and categorical data of the sample were presented as proportion or percentage.

RESULTS:

Out of 101 children, 18.7 % children were deficient in Fe while Zn deficiency was seen in 12.8 % cases . Prevalence of Combined deficiency was 3.9% . In both Group A & Group B, Fe deficiency was 20.6% & 11.9% , followed by zinc deficiency in 11.8% &7.5% and combined deficiency in 5.9% & 3.0% cases respectively. Zinc deficiency & combined deficiency (Fe & Zn) were more common in males while Fe deficiency was having female preponderance (M :F= 1:1.5). There was non - significant improvement in anthropometric measurements after supplementation i.e. weight, height and BMI in all deficiencies group i.e. Fe deficiency, Zn deficiency and combined deficiency as well as in control.

Verbal and Non- Verbal aspects of memory was affected in both age groups due to deficiency of Iron and Zinc. Verbal memory and Concentration showed statistically significantly affection in the 6-8 years age group.

Significant affectation of Verbal, Non - Verbal memory and Concentration was seen in 9-11 years age group [Table 1]. In 6 –8 yr age group, Verbal memory is mainly affected in Fe deficiency which was improved after supplementation & significant improvement was also seen after combined supplementation of Fe & Zn in Combined deficient group. While In 9 – 11 yr age group, Zinc deficiency mainly affects the verbal memory which was improved significantly after zinc supplementation [Table 2]. Non-verbal memory was mainly affected in 9-11 years of age group by deficiency of Iron, Zinc and their combined deficiency, the greater in the combined deficient group & improved significantly af-

ter supplementation of deficient micronutrient [Table 2]. Concentration scores were improved significantly in both age groups after supplementation of deficient micronutrients [Table2].

DISCUSSION

The age for cultivating inspiration and wisdom is from 6-8 years, and 9-11 years is considered to be important in the formative process and reasoning. This is the reason for the focus of our study in this particular age group. Memory is an important tool for a good academic performance and plays an important role in modifying the child's potential for learning, which influences behavior.

Tests of verbal memory assess the immediate verbal memory

After supplementation of deficient micronutrient for 3 months, 6-8 years age group showed marked improvement, particularly in the combined deficiency group, suggesting a greater tendency to revert to the normal growth. A study

Group A (6-8 Yr)	(1)Iron Deficiency [n= 7]	(2)Zinc Deficiency [n = 4]	(3)Combined Deficiency [n = 2]	(4)Control [n = 21]	p- Value
Verbal Memory	6.43 ± 3.6	8 ± 2.28	6 ± 0.0	11.05 ± 2.29	<0.001
Non-Verbal Memory	9.14± 4.34	8.75 ± 5.19	9.5 + 6.36	14.09 ± 3.60	>0.05
Concentration	28 ± 1.53	28.75 ± 1.26	20.5 ± 0.71	29.38 ± 2.22	<0.001
Group B (9-11yr)	(5)Iron Deficiency [n = 8]	(6)Zinc Deficiency [n = 5]	(7)Combined Deficiency [n = 2]	(8)Control [n=52]	
Verbal Memory	11.75± 2.71	8.8 ± 2.95	7.5 ± 0.71	11.40 ± 1.99	< 0.01
Non-Verbal Memory	15 ± 2.88	15 ± 3.08	10.5 ± 0.71	15.75 ± 1.57	< 0.01
Concentration	28.87 ± 1.88	25 ± 5.66	22 ± 12.73	28.79 ± 2.14	<0.05

Table 1: Memory Scores in Different Groups before Supplementation

*Significance by One way ANOVA test: all values are in Mean ± SEM

Group A (6-8 Yr)	(1)Iron Deficiency [n= 7]	(2)Zinc Deficiency [n = 4]	(3)Combined Deficiency [n = 2]	(4)Control [n = 21]	p- Value
Verbal Memory	4.14 ±1.67	1.25 ± 1.5	4 ± 0	0.95 ±1.43	<0.001
Non-Verbal Memory	3.14 ±1.67	4.25 ± 3.2	2 ± 2.83	1.61 ±1.98	>0.1
Concentration	2.14 ±1.06	1.75 ± 0.5	7.5 ±3.53	0.42 ± 2.61	<0.01
Group B (9-11yr)	(5)Iron Deficiency [n = 8]	(6)Zinc Deficiency [n = 5]	(7)Combined Deficiency [n = 2]	(8)Control [n=52]	
Verbal Memory	0.25 ±1.38	3.4 ± 2.5	1 ± 1.41	0.75 ± 2.13	<0.05
Non-Verbal Memory	2.62 ±2.92	2.8 ± 3.03	4.5 ± 2.12	0.36 ± 1.64	<0.0001
Concentration	2.12 ±1.88	5.2 ± 5.02	5 ± 7.07	1.23 ± 2.17	<0.001

Table 2: Improvement in Memory Scores after Supplementation

*Significance by One way ANOVA test: all values are in Mean ± SEM

in Wechsler intelligence scale for Fe deficient children of 6-8 years for items on verbal and performance subtests were improved with iron supplementation. Bruner *et al* [5] observed that after the 8-week supplementation of iron in girls, who performed better on a test of verbal learning and memory than girls in the control group. Tamura *et al* [6] observed that with zinc deficiency in 5 years old children, there was no change in Verbal ability scaled score and Auditory Sequential Memory score.

For the assessment of Non verbal memory in our study, we have used Benton visual retention test and Cattell retentivity test. These tests evaluate immediate memory and visuospatial abilities using visual designs. Non-verbal memory was mainly affected in 9-11 years of age group by deficiency of Iron, Zinc and their combined deficiency. After supplementation of deficient micronutrient for 3 month, 9 – 11 yr age group showed statistically significant improvement in Non –Verbal memory in all deficient group.

Chellappa *et al* [7] studied the effect of Iron and Zinc supplementation on cognitive functions of female adolescents in Chennai and observed that groups supplemented with Fe and combined i.e. Fe & Zn scored higher on the cognitive function of visual memory than the Zn and control groups. Based on their findings it appears that the cognitive function of visual memory is influenced more by iron status than zinc status. While, we have found the significant improvement in non- verbal memory score in all 3 deficient group supplemented with Iron, Zinc and Combined (Fe &

Zn) as compared to control.

Umamaheshwari *et al* [3] concluded that Non Verbal memory depend on both Iron and Zinc in both the age groups (i.e. 6-8 yr & 9 -11 yr). Both age groups are significantly affected in visual memory with more affectation in the combined deficiency subgroup. While, we have found that Non – verbal memory was significantly affected in 9 – 11 yr, more in combined deficient group. Penland *et al* [8] used extensive neuropsychologic battery of tests to asses cognitive and psychomotor functions in 6-9 year old children and observed zinc supplementation improved performance on tasks assessing visual recognition memory. Soemantri *et al* [9] showed that iron treatment group obtained a significantly higher score on Non verbal test than that in placebo.

The concentration test is a measure of attention maintenance, requiring accurate visual discrimination among different graphic stimuli over a given period of time. Concentration was significantly affected in both age & after supplementation there was statistically significant improvement in concentration scores noticed in both age group.

In 6 – 8 yr, combined supplementation of Fe & Zn in Combined deficiency group has statistically significant improvement in concentration scores as compared to other group. In 9- 11 yr, significant improvement in concentration scores was seen in all groups. In 6 – 8 yr age group, Fe & Zn both are having role in concentration of an individual as statistically improvement was seen by their supplementation in combined deficient group. While in Older children (9 -11 yr), Fe & Zn individually as well as their combined deficiency affect the concentration score as significantly.

Soemantri *et al* [9] showed that Changes in the iron status of iron-deficient anemic children were associated with significant changes in their performance on the school achievement and concentration tests. Agarwal *et al* [10] concluded that the anaemia is associated with lower levels of attention and concentration in 6 – 8 yr aged children similar to our study.

The lack of significant improvement in cognition / memory in this study could be attributed to the possibility of other coexisting micronutrient deficiencies such folate, riboflavin, vitamin C and vitamin B-12 in the population studied. This inference is supported by the findings of Goodwin *et al* [11] who found significant correlation between biochemical indices of vitamin status and cognitive functioning. They reported significant correlation between folate, riboflavin, vitamin C and vitamin B-12 status and memory capacity.

We conclude that Iron and zinc deficiency is associated with memory deficits in children. There is a marked improvement in memory & concentration after supplementation. Identification of the common micronutrient deficiency at an early age and proper supplementation would prevent derangement in cognitive function in the later age. Additional studies should be conducted to examine the recommendation of giving iron and zinc together for better expression of cognitive potential in school age children.

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