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The Effect of Zinc Supplementation on Cognitive Performance in Schoolchildren

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Abstract

Introduction

Zinc is a vital micronutrient in humans and its deficiency in children can thwart their growth and development, compromise their immunity and cognitive function. However, there is a paucity of studies about the effect of zinc supplementation on cognitive functions. This study is an attempt to quantify the impact of zinc supplementation on cognitive performance of schoolchildren.

Materials and Methods

This randomized, double-blind, placebo-controlled field trial was carried out in public elementary school in Mashhad- Iran to investigate the effect of Zinc on cognition of 45 healthy children. The cognitive test used in the trial was Raven IQ (Intelligence Quotient) test. A total of 45 first grade children aged 6 to 8 years were enrolled and divided into two experiment and control groups. The cases group, received 20 mg of zinc sulfate syrup vs. the control group received a placebo each day for 6 months. Raven IQ test was administered under basal conditions before and after the supplementation of zinc or placebo.

Results

The memory and intellectual development in the experimental group was significantly more than in the control group ($P < 0.05$).

Conclusion

The results of the study demonstrate the positive relationship between zinc administration and some aspects of intellectual development and personality features, emphasizing the significance of this element in the normal psychological status of children.

***Key Words**:* Cognitive function, Intellectual development, School children, Zinc.

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1- Introduction

Zinc is an important micronutrient for humans. A study based on plasma zinc concentrations (plasma zinc, 100 mg/dl) reported 65% zinc deficiency among schoolchildren in Tehran (1). Also, plasma zinc concentrations were observed to be low (10 mmol/l) in 51.5 and 58.3% of Sri Lankan boys and girls respectively (2). The preliminary symptoms of zinc deficiency in marginally nourished children are anorexia, reduced taste acuity and impaired cognitive function (3). The role of zinc in brain function and cognitive development is commonly studied in animal models rather than in humans. Although the exact mechanisms are not clear, it appears that zinc is essential for neurogenesis, neuronal migration and synaptogenesis and its deficiency can affect neurotransmission and subsequent neuropsychological behavior (4). The literature suggests that children and adolescents with poor nutritional status are susceptible to impaired mental and/or behavioral functions, which can be corrected by dietary measures to a certain degree (5).

In humans, zinc deficiency can hinder the activity, attention, and emotional behaviors, resulting in memory loss and impaired learning ability, language, and intelligence (4). Zinc is vital for brain development and brain function (6). Zinc homeostasis in the brain, tightly regulated by the blood–brain and blood–cerebrospinal fluid barriers, is not easily disrupted by dietary zinc deficiency (7). Zinc is mostly concentrated in the limbic system, i.e., the hippocampus and amygdala, with a large portion of zinc being incorporated into zinc metalloproteinase in neurons and glial cells functions (9, 8). However, dietary zinc deprivation may influence zinc homeostasis in the brain, resulting in brain dysfunction and occasionally dramatic and irreversible learning and memory problems (8, 9).

The studies on zinc supplementation in neonates and children provide some evidences that zinc influences neuropsychological behavior. For example, zinc supplementation to neonates have been shown to improve motor development scores and reverse some poor behaviors, particularly responsiveness (11, 10) with zinc administered to infants having a beneficial effect on motor development and orientation–engagement (2). Moreover, the beneficial effect of zinc supplementation on short-term memory has been consistently reported in children aged 5–15 years (12, 13); although other studies of infants and children have reported negative results (14, 15). The effects of zinc interventions on the cognitive performance of pre-adolescents have not been adequately addressed in the literature. Therefore, this study aimed to determine whether zinc supplementation can improve the score of Raven IQ test.

2- Materials and Methods

This study was conducted in the time period between December 2010 to June 2011 at state-run primary schools in Mashhad, North East of Iran. The students mainly came from low socioeconomic background. 45 healthy boys aged 6-8 years were randomly divided in two groups, 23 in the experimental group (51.1%; mean age of 7±1 years) and 22 (48.9%; mean age of 7±1 years) in the control group.

The study was a randomized, double-blind, placebo controlled trial in which neither the children nor the health worker knew about the contents of the syrups. Children had no taken any micronutrients two weeks before the start of study and they were not allowed to consume any during the course of study. Baseline data were collected on the age, weight, height and food intake.

Children received a treatment comprised of 20 mg Zinc sulfate syrup and the placebo contained a cellulose substance given in the identical syrup. Nursing students gave the supplement to each classroom during the school days for six months. For children who missed school for extended periods of time, parents received adequate syrup for supplementation at home. The health workers recorded morbidity-related information every week and obtained anthropometric measurements of the children at the baseline and at the end of the study period.

In this study, the children's psychomotor development and behavior were assessed by the Raven test, standard variant (a nonverbal intelligence test, non-influenced by the educational activity). This is a nonverbal test of performance that measures the ability to develop perceptual relations and reasoning through analogy and comparisons in research settings. It is an "average" level test that can be administered to children from 6 to 16 year olds. The test consisted of 5 sets of diagrammatic puzzles exhibiting serial change in 2 dimensions simultaneously. Each puzzle has a missing part that should be identified among the options provided (Figure.1). There is no time limitation in this test. The results allow the calculation of IQ, along with the visual, spatial perception, synthesis and analysis ability, comparison, learning, attention concentration and distribution.

2-1. Inclusion criteria, data extraction

All healthy boys aged 6 to 8 years could participate in the study upon the formal consent of their parents. The participants had no consumed any micronutrient 2 weeks before the study and they were not allowed to intake any during the course of study. Participants were randomly assigned to a zinc supplementation and a control (placebo) group. The intervention lasted for 6 months during which the additive effect of zinc was measured and some cognitive performance was assessed objectively. Exclusion criteria were chronic infectious or inflammatory diseases as well as surgery or consumption of vitamin and mineral supplements.

2-2. Ethical Considerations

A written consent was obtained from the parents of children before the study, and the protocol was reviewed and approved by the Ethics Committee on Human Research of the Mashhad University of Medical Sciences. RCT number is IRCT138711021162N9.

2-3. Statistical analysis

A sample size of 45 subjects was selected to provide an average statistical power of 95% with the aim of detecting the difference between the values of various parameters at baseline and after supplementation. The children's weight and length were measured by standard techniques. Independent-sample t- tests were used to compare the results of the treatment and placebo groups. The normality of data was evaluated using Kolmogorov-Smirnov test and SPSS version 13 was used for data analyses.

3- Results

After final screening, 45 eligible participants were selected. They were then randomly assigned to two zinc (n=23) and placebo (n=22) groups. The mean age of participants was 7±1 years in the Zinc group and 7 ±1 years in the placebo group (Table. 1). The participants were not significantly different in terms of demographic characteristics ($P > 0.05$). The two groups were relatively homogeneous in terms of average nutrient intake from complementary foods at the baseline. After zinc supplementation, a significant increase was observed in the Raven score of the experiment group ($P < 0.05$) whereas the raven score of the control group remained unchanged ($P > 0.05$). This indicates the beneficial effect of zinc supplementation on the sequencing score of Raven test (Table.3).

Table 1: Baseline Characteristics of boys

Parameter	Case group	Control group
Age (y)	7±1	7 ±1
Weight(kg)	20.37±2.21	20.92±1.98
Height(cm)	116.67±5.7	117.50±2.8
Head Circumflex(cm)	49.79±1.57	50.58±1.41
*Differences between control and experiment group for all parameters were not significant (p > 0.05).		

Table 2: Post-Baseline Dietary Measures and Other Independent

Parameter	Case group	Control group
Weight(kg)	21.65±3.0	21.90±2.0
Height(cm)	122.93±5.5	122.97±3.8
Head Circumflex(cm)	51.26±1.46	51.68±1.26

Table 3: Mean Cognitive Test Scores

Cognitive Test	Case group		Control group	
	Mean	SD	Mean	SD
Ravens Matrices. Pretest	14.43	3.17	16.41	5.72
Ravens Matrices.post test	21.70	4.33	16.90	4.16
*The test scores significantly increased at the end of study (paired t-test, p<0.05).				

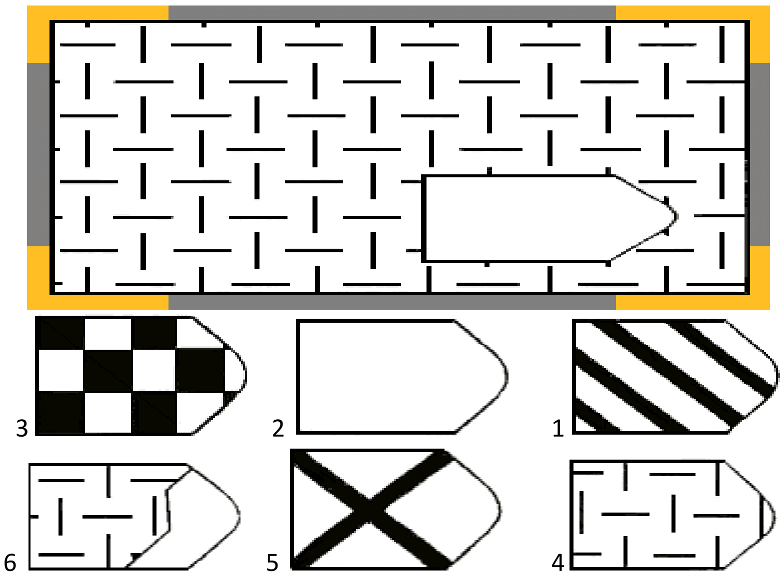

Fig.1: The Raven test

4- Discussion

This study examined the effect of Zinc supplementation on improving the cognitive performance of schoolchildren. The findings demonstrated that zinc-supplemented children had significantly higher IQ than children in the placebo group. The findings were not affected by the socioeconomic background of the families as two groups were controlled for any difference in socioeconomic status.

Some of the recent studies show that the brain is easily susceptible to metabolic changes associated with the pattern of meals and fasting (5). Various studies have shown that micronutrient supplementation can help improve intelligence quotient (IQ) scores in young people with nutritional diets especially in terms of main micronutrients (5).

Zinc is important for myelination and the release of the neurotransmitters Gamma-aminobutyric acid (GABA) and glutamate, which makes it essential to the cognitive function of children (4). A study showed that 20 mg/d zinc coupled with other micronutrients had a positive effect on reasoning and visual recognition of Chinese children (16), with the zinc supplement leading to a significant cognitive improvement in Mexican American school-aged children (17). In another study, supplementation with a liquid fortified with a range of micronutrients significantly improved attention-concentration in 6 to 15-year-old Indian children over 14 months, though no significant improvement in memory, IQ score or school action of children was observed (18). This might be due to high nutrient intakes of the hostel students at the baseline.

In our study, the baseline values of nutrient intakes were below Relationship Development Intervention (RDI) and mean cognitive scores were not above average. Our results suggested that zinc supplementation improved cognitive performance of school-age boys. Other factors such as socioeconomic status and stimulation in the home environment have been shown to influence the cognitive performance of children. In this study, the participants came from low income families and shared a similar environment at home. Although these factors were not controlled in this study, the randomization of boys into two groups can largely minimize the interfering effects of these variables.

5-Acknowledgment

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Conflict of Interest: None.

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