THE RELATION OF ZINC DEFICIENCY LEVEL ON MEMORY OF SCHOOL-AGE CHILDREN

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Abstract

More than two billion people are expected to lack of essential vitamins and minerals, especially vitamin A, iodine, iron (Fe) and zinc (Zn). Research showed positive effect of zinc supplementation on children's growth, morbidity and mortality in diarrhea and pneumonia. Zinc plays an important role in the structure and function of the brain; and zinc deficiency also has negative impact the development of cognitive functions such as attention and memory. This paper aims to determine the effect of zinc deficiency on memory in school-age children in the district of Klaten. The study used was description of analytic with quantitative approach by using *cross-sectional design*. The experiment was conducted in some elementary schools (SD) in the district of Klaten. The study population was the students from 9-12 age groups in the elementary schools, which in accordance with inclusion and exclusion criteria. This study employed *purposive sampling technique* to represent the elementary schools of villages and towns. The determination of the samples was done by PASS *software* and the number of sample was 60. The data were analyzed by using univariable and bivariable by statistical test *t-test* with 95% confidence intervals. The findings showed that children with zinc deficiency had the average value of 6.1 short-term memory with SD 1.3, whereas children with normal zinc levels had the average value of 10.7 and SD 3.1. The mean difference of -4.6 with 95 % CI (-6.98 - (-2.14) and a value of $p = 0.0004$ or $p < 0.05$. The average value of long-term memory of children with zinc deficiency was 7.8 with SD 3.0, whereas the average value of children with normal zinc levels was 8.4 and SD 3.2. The difference of the mean was -0.57 with 95 % CI (-3.16 - 2.01) and a value of $p = 0.658$ or $p > 0.05$. To conclude, the average scores value of short-term memory in children with zinc deficiency was lower than the short-term memory scores in children with normal zinc levels. The average scores value of long-term memory in children with zinc deficiency was equal to the children with normal zinc levels.

Keywords: zinc deficiency, short-term memory, long term memory, school-age children

Presenting Author's biography

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1. Introduction

Zinc (Zn) is a mineral that plays a central role in cell growth, particularly for the production of enzymes required for the synthesis of RNA and DNA. Zinc is commonly found in the brain and binding proteins, thus contributing to both the structure and function of the brain. Severe zinc deficiency in animals has been associated with malformations of brain structural such as *anencephaly, microcephaly, and hydrocephaly*, behavioral problems such as decreased activity, deficits in short-term memory and *spatial learning*. In humans, severe zinc deficiency can cause abnormal function before and destructive behaviors and emotional responses [(1)].

Age is an important factor to be considered in the correlation between levels of *zinc* deficiency and cognitive development of children because infants and teenagers are highly vulnerable to zinc deficiency during a period of rapid growth and development. *Zinc* deficiency in children causes many problems in the development of cognitive and motor function. In premature infants, having nutritional problems and chronic diseases that interfere with the absorption or growth make them more vulnerable and are at high risk of having cognitive and motor function defects [(2)].

The purpose of this study was to determine the influence between the levels of *zinc* deficiency with memory in school-age children. Another goal was to determine the average of zinc level in zinc-deficient children, the average value of short-term memory in children with deficient levels of zinc, the average value of long-term memory in children with deficient levels of zinc, as well as the influence of other factors on memory such as hemoglobin level, socioeconomic status, and nutritional status.

2. Data and Methods

This research was considered as quantitative study with a *cross-sectional* study design, which is a study about the dynamics of the correlation between risk factors and effects, by means of approach, observation or data collection conducted at once at a specific time. This study aims to assess the effect of zinc deficiency as the independent variable and short-term memory (STM) and long-term memory (LTM) as the dependent variable. The study population was all children of elementary schools in the district of Klaten .

The inclusive criteria for this study were: a) the elementary school students from the age group of 9-12 years old; b) children who had breakfast; and c) children with Hb within normal limits. On the other hand, the exclusive criteria in this study were: a) children who were sick (i.e., diarrhea and/or ARI) for the last three days; b) children with history of head injury; and c) children who were in the course of treatment/drug consumption. The sample size of this study was determined by using *PASS software* to test hypotheses for the two populations (*two-sample t-test*). The calculation of sample size was based on research conducted by Kar *et al*. [(3)], with mean1:4.2 and mean2: deviasi1 standard: 7.6 and the standard deviasi2: 2.1 with power 80%, α: 0.05, it was obtained number N1 and N2: 60 children.

The independent variable was deficiency of zinc levels serum, the dependent variable was memory in elementary school-age children, which consisted of STM and LTM. Confounding variables were hemoglobin level, socioeconomic status and nutritional status.

Zinc levels and hemoglobin levels were determined by AAS technique (*Atomic Absorption Spectrophotometer*); short-term memory was measured using the instrument WISC subtest *Digit Span Memory Test*, namely *Digital-Span Forward* and *Backward Digital-span*. The assessment of long-term memory was done with the recall of narrative/story. In this test, children were asked to respond in writing after listening to a story. *Recalling* was done twice, the first was 15 minutes after listening to the story and the second was conducted after two weeks later. Nutritional status was determined by Body Mass Index (BMI) by age. Categories and thresholds of nutritional status of children was based on the index according to the Ministry of Health [(4)]. The economic status of the family was seen from income earned by the family during the month, calculated by adding father's and mother's income. The measurement results were stated based on poverty line in Central Java province in urban and rural areas set by BPS in September 2012.

Univariable analysis was used to determine the frequency distribution of the independent variable, dependent variable, and external variables, displayed in the form of a frequency distribution table. The *mean* and *standard deviation* was used for the numerical scale data, namely the dependent variable of blood *zinc* levels, independent variable of short-term memory and long term memory, and confounding variable such as anemia and nutritional status.

Bivariable analysis with statistical test *Independent T - Test* with CI 95%, p< 0.05 was used to determine the correlation between independent variables, namely the level of zinc deficiency on the dependent variable of short-term memory, long term memory and external variables, namely anemia, socioeconomic status and nutritional status. Multivariable analysis by modeling is conducted by using linear regression statistical test with a significance level of p<0.05, CI 95%, assuming that there was correlation between the independent variable (i.e., zinc deficiency level) on the dependent variable (i.e., short-term memory and long-term memory), and external variables (i.e., anemia, socioeconomic status and nutritional status).

3. Results

Univariable analysis was conducted in the form of respondent characteristics, and it was conducted to determine the characteristics of the respondents before the categorization based on the independent variable such as levels of zinc, , dependent variable such as *short term memory* and *long term memory*, and confounding variables such as hemoglobin level, nutritional status, and socioeconomic status. The characteristics of respondents can be seen in Table 1 and Table 2.

Tabel.1 The Characteristics of respondent

Variable	**The Tendency Measurement**			
	n	**Mean±SD**	**Min**	**Max**
Age	65	10.65±0.73	9.0	12.1
Weight	65	32.10±10.23	19	65
Height	65	138.29±7.97	123	157
BMI	65	16.52±3.92	11.7	27.1
STM	65	10.58±3.09	5	18
LTM	65	8.36±3.20	1	15
Zn Level	65	78±12.70	48.5	110
HB	65	13.6±1.13	10.6	15.6
Soc-Eco	65	640058.6±482002.6	120000	2142857

Table 2. The Characteristic of Respondent based on Variables of Study

Variables	**n**	**%**
Zinc Level		
deficiency	7	10.8
normal	58	89.2
Hb level		
Anemia	2	3.1
Normal	63	96.9
Socioeconomic		
Low	13	20
High	52	80
Nutritional Status		
Not Normal	24	36.9
Normal	41	63.1

Bivariable analysis was conducted between the independent variable (i.e., zinc level) and dependent variable of short term memory and long term memory, and external variables including hb levels, nutritional status, and socio-economic status.

Bivariable analysis was conducted by using *t-test*. Prior to conducting t-test, the analysis of data homogeneity was done. Homogeneity of data was done by using the Fischer Exact Test and homogeneity analysis results showed no significant evidence. Test results of *independent t-test* between zinc levels to *the sort term memory* and *long term memory* were shown in Table 2. Test of *independent t-test* between the external variables to *the sort term memory* and *long term memory* were shown in Table 3.

Table 3. The test of Independent t-test between Zn Level to the STM and LTM

Variable	**STM** Mean ± SD	**Δ mean**	***t***	***p*** **95% CI**	**LTM** Mean ± SD	**Δ mean**	**t**	***p*** **95% CI**
Zn Level								
Deficiency	6.1 ± 1.3	-4.6	-3.8	0.0004	7.8 ± 3.0	-0.57	-0.01	0.658
Normal	10.7 ± 3.1			-6.98 – (-2.14)	8.4 ± 3.2			-3.16 – (2.01)

The researcher conducted bivariable analysis by using *t-test*, which was by using a specified significance level of $p<0.05$. Based on Table 3, the results of bivariable analysis could be concluded that there were significant differences in terms of STM between students with zinc deficiency and students with normal zinc level (p 0.0004). In contrast to short-term memory, the analysis results of independent t-test of the levels of zinc deficiency on LTM (long term memory) showed no significant results. Even though the average value of the LTM for the group of normal zinc levels was higher than 0.57 points, but it showed insignificant result with p value = 0.658. These results confirmed the second hypothesis, that average of long-term memory of children with zinc deficiency was not different from children with normal zinc level.

Table 4. Test of Independent t-test between Hemoglobin, the Socio-Economic and nutritional status to the STM and LTM

Variable	**STM** **Mean ± SD**	**Δ mean**	***t***	***p*** ***95%CI***	**LTM** Mean± SD	**Δ mean**	***t***	***p*** ***95%CI***
Hemoglobin								
Anemia	15 ± 3.6	5	2.67	0.0096	10 ± 2	1.71	0.90	0.372
Normal	10 ±3.2			1.27-8.77	8,3 ± 3,2			-2.09 – (5.51)
Socio Economic								
Low	8.3 ± 3.0	-2.4	-2.39	0.019	6,9 ± 2,9	-1.81	-1.85	0.068
High	10.7 ± 3.2			-4.37-(-0.39)	8,7 ± 3,2			-3.76 – (0.14)
Nutritional Status								
Not normal	10.2 ± 3.0	-0.01	-0.01	0.99	8,4 ± 3,2	0.01	0.01	0.991
Normal	10.2 ± 3.5			-1.73-(1.71)	8,4 ± 3,2			-1.65-(1.67)

Based on Table 4, the results of Bivariable analysis between the dependent variable STM to the independent variable showed a significant association with hemoglobin level and socioeconomic status but not significant to the nutritional status. The results of the analysis between LTM to external variables showed no significant correlation to all external variables, which were hb levels, socio-economic status, and nutritional status.

4. Discussion

The results of this study indicated that zinc deficiency level affected short-term memory with p value = 0.0004. The significant results between the levels of zinc deficiency on the STM showed that the results of this study were in accordance with some previous studies. The studies conducted by Umamaheswari *et al.* [5] in India, showed that iron and *zinc* deficiency was associated with memory impairment in children. They were able to make a memory enhancement after administration of *zinc* supplementation but did not improve IQ scores in children from age group of 6-8 years old. According to Levenson and Morris[6], derived from the available data about *zinc* deficiency, both during growth and adulthood, would reduce the ability of *neurogenesis* through a limited number of *neural precursor cell proliferation* in the CNS, this was due to a decrease in cell proliferation and increased of apoptotic cell death.

In contrast to short-term memory, the results of independent t-test analysis of the levels of zinc deficiency on LTM (long term memory) showed no significant results. Even though the average value of LTM for the group of normal zinc levels was higher than 0.57 points, the results did not show significant result with p value = 0.658. These results answered the second hypothesis: that the average of long-term memory of children with zinc deficiency was not different to children with normal zinc. In line with Sherwood's theory[7], the storage of long-term memory seems to involve more permanent physical changes in the brain, that was the change which is able to withstand in the exchange of substances of cells continuously for many years. There was no formation of new neurons, but structural and functional changes could happen, which were more settled between the existing neurons. For example, the formation of new synaptic connection, permanent changes in membrane pre-or post-synaptic, or an increase or decrease in the synthesis of neurotransmitters. Memory loss on long-term memory is only possible if someone is having a functional impairment of the memory system.

5. Conclusion

Based on the results of this study, it could be concluded that 1) the average value of zinc levels in zinc deficient group was 57.4 mmol/dl; 2) the average value of short-term memory scores in the group of zinc deficiency is 4.6 points, lower than short-term memory scores in the group of normal zinc levels; 3) the average value of long-term memory scores in the group of zinc deficiency was similar to the normal zinc levels. There was only 0.57 points difference, lower than the score of long-term memory of normal zinc level group. Fourth, there was a significant correlation between the levels of zinc deficiency on short-term memory. Fifth, there was no significant relationship between the levels of zinc deficiency on long-term memory.

6. Recommendation

Based on the above conclusions, the researcher made some suggestions: 1) To the health personnel at the community health center to conduct health education in schools either to the students or parents about the importance of increasing intake of zinc in children's daily diets in order to increase the capabilities of short term memory of the children; 2) To the elementary school officials, in order to work with stakeholders, to conduct an evaluation program or screening of the student's academic ability related health problems; therefore, students can optimize their cognitive potential in learning; 3) To the parents of students, to pay more attention to the adequacy of foods containing enough nutrients needed by body for growth and development of children; 4) To the cadre of health volunteers or neighborhood health center, to improve the provision of information/education on the benefits of zinc in the wider communities, in which one of the benefits is to improve the children's memory skills; 5) For future studies, in order to examine the factors that affect the ability of long-term memory upgrades.

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