

Impact of Iron Deficiency on Cognition in School Age Children

Nova Lidia Sitorus^{1*}, Irma Nuraeni Salsabila

¹Danone SN Indonesia, Jakarta, Indonesia, ²Ridwan Institute

*Correspondence: nova.sitorus@danone.com

ABSTRACT: Iron deficiency is a significant global health problem, especially among school children. Iron deficiency has a serious impact on children's health, including cognitive development. The aim of this study was to investigate the impact of iron deficiency on cognitive function of school-aged children. This study used a cross-sectional design. The study sample was school-aged children who met the inclusion criteria. The inclusion criteria were children aged 6-12 years, had hemoglobin <12 g/dL, and had no other chronic diseases. Exclusion criteria were children who were undergoing certain drug therapy, children who had other cognitive developmental disorders, and children who had a history of allergy to iron. Data were collected through interviews, physical examinations, and laboratory tests. Data were analyzed using descriptive statistical tests. The results showed that iron-deficient children had lower cognitive function than non-iron-deficient children. This is indicated by lower scores on cognitive tests, such as memory, attention, and learning ability tests. Therefore, it is important to prevent and treat iron deficiency in school-age children.

Keywords: Iron Deficiency, Cognitive, School-Age Children

INTRODUCTION

Iron deficiency anemia is a medical condition that occurs due to a lack of iron in the body. This iron deficiency causes the number of healthy red blood cells, or hemoglobin, in the body to decrease and not function optimally. When the body lacks iron, the body's ability to produce healthy red blood cells is impaired. Red blood cells are formed with the help of iron, and the hemoglobin in red blood cells functions to bind and transport oxygen from the lungs to the various organs of the body. Red blood cells also play a role in removing carbon dioxide from the body's cells to the lungs. Without an adequate supply of iron, the body cannot produce adequate amounts of hemoglobin to transport

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oxygen. As a result, a person with iron deficiency anemia may feel tired easily and have difficulty breathing (Fadli, 2023).

Iron deficiency anemia is one of the most common hematological disorders found in infants, children, and women of reproductive age. In children, ADB can cause problems in growth, behavioral changes, and motor impairment, which in turn can hinder learning ability and reduce school performance. These adverse effects have the potential to affect the development of human resources. The main factors that cause iron deficiency anemia in women of reproductive age are menstruation and pregnancy (Kurniati, 2020).

The prevalence of iron deficiency anemia in Indonesia remains high, especially among pregnant women, children under five, school-age children, and low-income workers. In children in Indonesia, the incidence rate ranges from 40-50%. Results from the Household Health Survey (SKRT) noted that iron deficiency anemia occurred in approximately 48.1% of children under five and 47.3% of school children (IDAI, 2016). Iron deficiency is a systemic condition that has a variety of effects, including anemia, impairment in sports activities, and changes in small bowel function. One of the most concerning consequences of iron deficiency in children is changes in behavior and decreased cognitive performance (Halterman et al., 2001).

Cognitive development refers to a series of stages of change in human life that enable understanding, information processing, problem solving, and knowledge. Jean Piaget, a scientist with a background in biology, is one of the leading figures who studied cognitive development and identified key stages in this process. Piaget linked mature physical development to cognitive development, and he described four main stages in cognitive development, namely the sensorimotor stage (0-2 years), pre-operational stage (2-7 years), concrete operational stage (7-11 years), and formal operational stage (11-15 years). In their efforts to actively understand the world, children use concepts such as schema (framework of knowledge), assimilation (integration of new information into an existing framework), accommodation (adjustment of schema to accommodate new information), organization (grouping information into a larger framework), and equilibration (balancing between assimilation and accommodation) (Marinda, 2020).

Previous research by (Agaoglu et al., 2007) showed that iron deficiency anemia in children can affect long-term cognitive function. WISC-R intelligence subtests and IQ scores before and after treatment in the IDA group were significantly different from the control group. Another study by (More et al., 2013) showed the results of Scholastic Performance, IQ and Mental Balance Score, Attention & Concentration, Verbal Memory and Recognition decreased in iron deficient girls, both anemic and non-anemic compared to girls who were not iron deficient.

The novelty of this study is that there is no research on the impact of iron deficiency on cognition in school-aged children 6-12 years old in X Village, X District, X Province. This study emphasizes the importance of monitoring the nutritional status of school-age children, especially their

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iron intake. The implication is that there is a need to prevent and treat iron deficiency in children, which can improve their overall health. The aim of this study was to investigate the impact of iron deficiency on the cognitive function of school-aged children.

RESEARCH METHODS

This study used a cross-sectional design. According to (Notoatmodjo, 2002)), the cross-sectional method is a research approach that aims to examine the correlation between risk factors and effects at one specific point in time. This approach is carried out by means of observation and data collection at the same time to analyze the relationship between the variables studied. The population of this study were elementary school-age children in Tanjung Priok Village, Tanjung Priok District, Jakarta Special Capital Region Province. The research sample was school-age children who met the inclusion criteria. The inclusion criteria were children aged 6-12 years, had hemoglobin levels <12 g/dL, and did not have other chronic diseases. Exclusion criteria were children who were undergoing certain drug therapy, children who had other cognitive developmental disorders, and children who had a history of allergy to iron. Data were collected through interviews, physical examinations, and laboratory tests. Data were analyzed using descriptive statistical tests.

RESULTS AND DISCUSSION

Results

Out of 120 students aged 6-12 years, only 100 students agreed to participate in the study. Students then underwent three tests including hemoglobin concentration, serum ferritin, and cognitive function tests.

Table 1. Prevalence of Anemia in Students

Hemoglobin level	Number of students
<12 g/dL	72
>12 g/dL	28

Out of 100 students, 72 students had hemoglobin levels less than <12 g/dL and 28 students had hemoglobin levels above 12 g/dL. Thus, the prevalence of anemia in school-age students is 72% with characteristics of age 12 as many as 33, age 11 as many as 8, age 10 as many as 10, age 9 as many as 5, age 8 as many as 3, age 7 as many as 2 and age 6 as many as 0.

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Table 2. Hemoglobin Concentration Test

Hemoglobin level	Number of students
10 - 12 gm%	64
7 - 10 gm%	6
< 7 gm%	2

Of the 72 students who experienced anemia, 64 students (64%) had Hb values between 10 and 12 gm%, 6 students (6%) had Hb values between 7 and 10 gm%, and the remaining 2 students (2%) had Hb values below 7 gm%. Thus, mild anemia (Hb 10-12 gm%) was present in 64% of the study subjects, moderate anemia (Hb 7-10 gm%) in 6%, and severe anemia (Hb <7 gm%) was only present in 2% of the study subjects. In this study, 100 students aged 6-12 years underwent serum ferritin examination, and 64 of them were diagnosed with iron deficiency, which refers to a serum ferritin level of less than 12 µg/L, meaning that the prevalence of iron deficiency among this group was 64%. Of the 72 anemic students, 56 of them also had decreased serum ferritin levels. Considering that the total number of students was 100, the prevalence of iron deficiency anemia was about 56%, and the remaining 16 anemic children were the focus of further research.

Attempts to understand the cause of anemia in the 16 students who were anemic but not iron deficient involved follow-up examinations that included peripheral blood smears, reticulocyte type counts, and electrophoresis. The results showed that of these 16 students, 6 had sickle cell trait, 4 had sickle cell disease, 3 had thalassemia minor, and 3 had macrocytic anemia likely caused by vitamin B12 and folic acid deficiency. Therefore, these 16 students were not included in this study as their anemia cases had different causes.

Table 3. Cognitive Function Test

Test	Normal Iron Status	Iron-Deficient Without Anemia	Iron-Deficient With Anemia
	N = 44	N = 64	N = 56
	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)

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Memory	91.6 ± 17.5	90.1 ± 15.4	89.5 ± 15.9
Attention	86.5 ± 17.4	84.5 ± 16.8	83.8 ± 16.2
Learning Ability	8.2 ± 2.8	8.1 ± 2.8	7.7 ± 3.6

P < .05 compared to children with normal iron status, using Student's t test statistics

Table 3 shows the mean standardized values for memory, attention and learning ability tests by iron status. Results are shown for children with normal iron status, iron-deficient children without anemia, and for iron-deficient children with anemia. Mean memory scores were lower in iron-deficient children without anemia compared to children with normal iron status (90.1 : 91.6; P < 0.5). Iron-deficient children with anemia also had lower math scores compared to children with normal iron status (89.5 : 91.6; P < 0.5).

Attention test scores were lower in iron-deficient children without anemia compared to children with normal iron status (84.5 : 86.5; P < 0.5). Iron-deficient children with anemia also had lower math scores compared to children with normal iron status (83.8 : 86.5; P < 0.5). Ability scores were lower in iron-deficient children without anemia compared to children with normal iron status (8.1 : 8.2; P < 0.5). Iron-deficient children with anemia also had lower math scores compared to children with normal iron status (7.7 : 8.2; P < 0.5).

Discussion

The results of this study revealed that children who were iron deficient had lower levels of cognitive function when compared to children who had adequate levels of iron in their bodies. This difference was seen in lower scores on various cognitive tests that included tests of memory, attention and learning ability. According to these findings, iron deficiency can negatively affect children's memory, concentration and learning. The results of this study support the results of previous research by (More et al., 2013) which showed. That Scholastic performance, IQ and Mental Balance Scores, Attention & Concentration, Verbal Memory and Recognition decreased in iron deficient girls, both anemic and non-anemic compared to girls who were not iron deficient. Another study by (Haltermann et al., 2001) showed that iron-deficient school-aged children, including iron-deficient adolescents without anemia, had lower math achievement compared to those with adequate iron levels. Therefore, a screening process to detect iron deficiency in the absence of anemia may be necessary, especially in children at risk.

During their growing years, children require more blood-building substances. In addition, frequent infections in children can interfere with blood formation, which in turn will worsen the

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condition of anemia in children. Poor diet also plays a role in increasing the risk of anemia in children. Children who tend to eat light meals with insufficient nutrients will reduce their intake of iron necessary for blood cell formation. Iron deficiency anemia has a negative impact on children's health, such as impaired growth, decreased endurance, low concentration, and decreased learning ability which ultimately affects their performance at school (Putrihantini & Herawati, 2013).

There are several symptoms that occur in children with iron deficiency anemia such as weakness, lack of appetite, fatigue and inactivity. But in infants or younger children, they will have difficulty drinking. The signs of a child with iron deficiency anemia are mainly pallor. Pallor can be seen on the eyelids, on the palms of the hands, then on the oral mucosa. In addition, there are several signs that can occur in children with iron deficiency anemia, namely the child becomes difficult to concentrate and then their development becomes inhibited and they often get sick (Nurbadriyah, 2019).

It is recommended to give iron-rich foods to children as much as two servings a day. Also, fortified foods, such as sold cereals, can be an alternative to meet children's iron needs. In addition to food sources, the Indonesian Pediatric Association (IDAI) in 2011 recommended giving iron supplements daily to children from 4 months to 2 years of age. The dose is 2 mg of elemental Fe per kg of body weight per day for infants born full term, or 3 mg of elemental Fe per kg of body weight per day for premature or low birth weight infants (<2,500 grams). IDAI also suggested a maximum limit of 15 mg of iron per day for infants. However, IDAI in 2015 gave a warning to be careful in giving iron supplements, because research showed that the growth of children who were not anemic and had taken supplements was significantly slower compared to children who were not anemic and had taken a placebo. Another clinical trial study in 2016 showed that giving iron supplements to infants at a dose of 1 mg elemental Fe per kg of body weight has a positive impact on preventing anemia and is safe without the risk of side effects in children (Purnamasari et al., 2020).

CONCLUSION

Children with iron deficiency face reduced cognitive function compared to their peers who have sufficient iron levels. This impact is seen in the results of cognitive tests, which include measurements of memory, attention levels and learning ability. Children with iron deficiency showed lower scores in these tests, indicating a hindrance in their cognitive abilities. The results of this study therefore highlight the urgency for prevention and treatment of iron deficiency in school-age children. Efforts to ensure adequate iron supply in children's diets may contribute to their improved cognitive function, which in turn will support their development in the educational process. Future research could add additional variables to the study, such as general nutritional status, physical activity level and

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environmental factors, to better understand the factors that may influence the relationship between iron deficiency and cognition.

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