Paediatrica Indonesiana

VOLUME 49 July • 2009 NUMBER 4

Original Article

Academic achievement of elementary school-aged children with pre-anemic iron-deficiency

Paul Wiratama Pardede, Endang Windiastuti, Bambang Tridjaja

Abstract

Background Relationship between iron deficiency and cognitive function has been investigated in many studies, but they usually focused on iron deficiency anemia. Brain iron storage might have already decreased before anemia exist.

Objectives To investigate the prevalence of pre-anemic iron-deficiency in school-aged children and to determine whether this condition is a risk factor for low academic achievement.

Methods A cross-sectional study was conducted on 87 subjects of 2nd-6th grade in SDN 04 Petang, Kramat, Senen, Jakarta on August 2008. The subjects underwent peripheral blood and ferritin serum concentration examinations. Twenty-nine subjects who suffered from anemia were excluded. The remaining 58 subjects were classified into normal body iron status group and preanemic iron-deficiency group.

Results The prevalence of pre-anemic iron-deficiency in SDN 04 Petang, Kramat was 6%. The prevalence ratio to determine whether pre-anemic iron-deficiency was a risk factor for low academic achievement could not be calculated because the minimal sample number required was not reached. There was no relationship between pre-anemic iron-deficiency and low academic achievement for mathematics, Indonesian language, science, and social science.

Conclusions The prevalence of pre-anemic iron-deficiency in SDN 04 Petang, Kramat Senen Jakarta was 6%. This study is not able to determine whether pre-anemic iron-deficiency is a risk factor for low academic achievement in school-aged children; therefore further study with more efforts to detect the presence of iron deficiency in children with inflammation is needed. **[Paediatr Indones. 2009;49:209-13]**.

Keywords*: iron-deficiency, academic achievement, school-aged children, ferritin*

Iron deficiency is a global health problem not only in developing countries, but also in developed countries.[1-3] Iron deficiency in Indonesia commonly occur in pregnancy, children under 5 years of age, and school-aged children; especially those who come from low-middle socio-economic class.[3] The prevalence of iron deficiency should be higher than that of iron deficiency anemia, therefore iron deficiency has bigger influence on community health problem.[2,4,5] National Household Survey in 1995 showed that 40.5% children under 5 years of age and 47.2% School-aged children suffered from iron deficiency anemia, but the data of national prevalence of iron deficiency without anemia in Indonesia has not been established.[6] Windiastuti *et al*, as cited by Abdulsalam, studied that 115 of 383 (30%) elementary school students with normal hemoglobin level apparently had decreased serum iron level.[7] One of the important effects of iron deficiency in children and adolescents is impaired behavioural and cognitive function,[1,3,5,8-10] that will influence academic achievement.[4,5,7,9,11,12]

From the Department of Child Health, Medical School, University of Indonesia, Cipto Mangunkusumo Hospital, Jakarta, Indonesia.

Reprint request to: Paul Wiratama Pardede, MD, Department of Child Health, Medical School, University of Indonesia, Cipto Mangunkusumo Hospital, Jl. Salemba 6, Jakarta 10430, Indonesia. Tel. +62-21-3907742. Fax. +62-21-3907743.

A lot of studies have aimed to evaluate the relation between iron deficiency and cognitive function or academic achievement,[2,3,7,9,10] most of them usually focused on iron deficiency anemia. Usually body iron deposit including brain has already decreased before the decrease of hemoglobin production. Research by Soemantri *et al*[13] showed that iron therapy can increase children learning capacity, also it can compensate previous impairment that already occurred. Reports from some studies about relationship between pre-anemic iron-deficiency and academic achievement stated that there was correlation between iron deficiency without anemia and low academic achievement in school-aged children.[4,14] It indicates that children with pre-anemic iron-deficiency may have learning process disturbances that lead to low academic achievements. The prevalence of pre-anemic iron-deficiency in school-aged children in Indonesia has not yet been established. This study aimed to find the prevalence of pre-anemic iron-deficiency in school-age children and to know the proportion of low academic achievements in children with pre-anemic iron-deficiency compared to that in children with normal iron level.

Methods

This was a cross-sectional study carried out on 2nd to 6th grade of elementary school children, conducted in a Government Primary School (SDN04), Kramat, Senen Jakarta, in August 27-29, 2008. We included children whose parents gave informed consent, and excluded those with anemia or suffered from other chronic disease. We conducted history taking and physical examination. Blood specimen was sent to Prodia laboratory® for peripheral blood and ferritin level examinations. This study was approved by Board of Ethical Committee of Medical School University of Indonesia. Blood examinations were done in Prodia laboratory.

Iron status was classified into two groups: normal and iron deficiency without anemia. Children with iron deficiency without anemia were those who suffered from iron depletion and iron deficiency without anemia, with hemoglobin level ≥ 12 g/dl and serum ferritin level < 20 μg/dl. Anemia was defined as Hb level < 12 g/dl. Good academic achievement was a term for scores ≥ 60 in mathemathics, Indonesian language, science, and social sciences from the last term academic reports before the period research; scores < 60 was classified into low academic achievements. Chronic disease was a disease that occurred or has been estimated to be going on for three months or more, and affects daily activities.[15]

Data was processed with SPSS 15.0 and then presented in text and tables. Relation between iron status and academic achievement was analyzed using Fisher's exact test if the requirements for chi-square test were not fulfilled.

Results

Eighty-seven subjects met the inclusion criteria. Twenty-nine subjects were excluded due to anemia, consisted of seven subjects with iron deficiency anemia, and 22 subjects with anemia of other causes. Fifty-eight subjects consisted of 30 boys and 28 girls were finally included and classified into two groups based on serum ferritin level: 53 subjects with normal iron status and five subjects with iron deficiency without anemia (**Table 1**). Mathematics, Indonesian language, science, and social sciences academic achievements from subjects in each iron status group were classified into good academic achievement group and low academic achievement group (**Table 1**).

Table 1. Characteristics of subjects (N=58)

Characteristics	n	%
Sex		
• Boys	30	52
• Girls	28	48
Serum ferritin level		
• Without iron deficiency	53	91
• Iron deficiency without anemia	5	9
Mathematic academic achievement		
• Good	48	83
• Low	10	17
Indonesian language academic achievement		
• Good	56	97
• Bad	2	3
Social science academic achievement		
• Good	57	98
• Bad	1	2
Science academic achievement		
• Good	55	95
• Bad	3	5

From 87 subjects, the prevalence of pre-anemic iron-deficiency in this government primary school was 5.7%. The prevalence ratio of pre-anemic iron-deficiency as a risk factor for low academic achievements could not be calculated because of the small sample size. Fisher's exact test showed that there was no association between pre-anemic iron-deficiency and low academic achievements for mathemathics, Indonesian language, science, and social sciences (**Table 2**).

Tabel 2. Relation between iron status and academic achievement

Academic achievement	Body iron status		P
	Normal (N=53)	Iron deficiency without anemia (N=5)	
Mathematics			
• Good	44	4	1.00
• Bad	9	1	
Indonesian language			
• Good	51	5	1.00
• Bad	2	0	
Social sciences			
• Good	52	5	1.00
• Bad	1	0	
Science			
• Good	51	4	0.24
• Bad	2	1	

Fisher's exact test, two-way

Discussion

The prevalence of pre-anemic iron-deficiency found in this study was 5.7%, a number which was smaller than that of Windiastuti *et al* (30% of elementary school students).[7] The difference was probably due to the indicators used in assessing iron deficiency. This study used serum ferritin level, while Windiastuti *et al* used serum iron level. Soemantri in his study in 1978 found that 57 out of 77 (74%)[16] elementary school students who had not suffered from anemia, were actually in iron depletion stage based on serum iron level < 80 μg/dl, but when they performed serum ferritin level examination in 20 random subjects out of 77 subjects, all of them had normal serum ferritin level.[16] Another possible cause was the presence of inflammation that may affect serum ferritin level, so that children who actually had suffered from iron deficiency were falsely classified into normal group. This study also showed low level of MCV mean (77.1 fL) which was commonly found in thalassemia carrier, but this still needed further evaluation.

This study failed to indicate pre-anemic iron-deficiency as a risk factor for low academic achievement in school-aged children, because of small sample size. Inability to reach the minimal sample number required in pre-anemic iron-deficiencygroup was probably due to the serum ferritin level used as indicator in assessing body iron status in this study was being affected with inflammation. Worwood[17] reported that serum ferritin was the best indicator of depleted iron stores. However, serum ferritin is also an acute phase protein; which its concentration will rise during inflammation, so it will be difficult to interpret the concentration of ferritin in situations in which infectious diseases are common. As acute phase response to inflammation, interleukin-1β (IL-1β) and *tumor necrosis factor*-α (TNF-α) are released. There is an increased synthesis of ferritin H and L subunits, and then serum ferritin level will also increase.[18,19] Birgegard, as cited by Worwood, stated that in acute infection, serum ferritin level will increase three-fold, with maximum peak level reached in one week.[17] It was predicted that some children in this study who were classified into normal iron status group, were probably suffering from iron deficiency together with inflammation process. In this condition, serum ferritin level will be normal or even increase. Researchers had tried to anticipate the influence of inflamation on ferritin level by exploring history of any chronic diseases and doing some physical examinations, but those attempts probably inadequate to detect inflammation. Erythrocyte sedimentation rate or other acute phase protein examination should have been performed to more accurately detect the influence of inflammation on ferritin level. Some other acute phase protein examinations, such as C-reactive protein (CRP) can be used to interprete serum ferritin data. Soluble transferrin receptor (sTR) level measurement can also be used to detect iron deficiency in children with chronic inflammation,[20] but unfortunately it is quite expensive and not available yet in Indonesia. Combination of serum ferritin level, serum iron (SI) level and TIBC examinations will help to detect iron deficiency in children with inflammation. More over, some investigators use higher ferritin cut-off point in diagnosing iron deficiency in area with high prevalence of malaria or other infections.[21,22]

This study used Fisher's exact test to find the relation between pre-anemic iron-deficiency and academic achievement because the requirement for Chi-square test was not fulfilled. The result of Fisher's exact test showed that there was no relation between those two conditions, so that the hypothesis of this research was rejected. This is probably caused by several factors. First, the probable existence of inflammation in children with iron deficiency influenced serum ferritin level. This led to very small sample numbers in iron deficiency group and not enough to reach the minimal sample number required, which at the end will affect the statistical analysis result. Second, as explained before, the primary obstacle experienced in previous studies that were trying to find the relation between iron deficiency and academic achievement is the failure in controlling confounding factors that influence the academic achievement of a child.[10,13,14,20,21,23] In this study, investigator had tried to control exogenous factors that probably influence academic achievement, such as socio-economic condition, by taking subjects from relatively homogenous environment. All subjects lived in same district around school, with low-socioeconomic family background. Fathers worked as labor, driver, or even unemployed, and their mothers were mostly housewives or house maid. By choosing subjects from the same school, we tried to control other exogenous factors such as assignments standard, scores, teachers, and internal school environment that were assumed to be equal in all students. Unfortunately, factors influencing academic achievement could not be completely controlled in this research. It explain why there was low academic achievement in some children with normal iron status. This research has limitation in determining the onset of deficiency in children with iron deficiency. It was known that cognitive function will be more severely impaired if the iron deficiency occur in golden period of brain development.[21] Based on this theory, we predicted that iron deficiency in children with good academic achievement probably developed after the golden period of brain development.

In conclusion, the prevalence of pre-anemic iron-deficiency in SDN 04 Petang, Kramat, Senen Jakarta is 5.7%, but this study is not able to demonstrate that pre-anemic iron-deficiency is a risk factor for low academic achievement in school-aged children. Further study examining ferritin level, serum iron level, TIBC and soluble transfer receptor level examinations is needed in order to decrease the prevalence of low academic achievement in school-aged children.

References

1. West CE. Iron deficiency: The problem and approaches to its solution. Food Nutr Bull. 1996;17:37-41.
2. Looker AC, Dallman PR, Carroll MD, Gunter EW, Johnson CL. Prevalence of iron deficiency in the United States. JAMA. 1997;277:973-6.
3. Soemantri AG. Childhood iron deficiency anemia and IQ. JPOG. 1997;23:5-6.
4. Halterman JS, Kaczorowski JM, Aligne CS, Auinger P, Szilagyi PG. Iron deficiency and cognitive achievement among school-aged children and adolescents in the United States. Pediatrics. 2001;107:1381-6.
5. Setianingsih I. Anemia defisiensi besi dan prestasi. In: Wahidiyat I, Gatot D, Mangunatmaja I, editors. Naskah Lengkap Pendidikan Kedokteran Berkelanjutan Ilmu Kesehatan Anak FKUI XXIV. 6-7 Sept 1991. Jakarta: Balai Penerbit FKUI, 1991; p. 79-94.
6. Departemen Kesehatan RI. Profil Kesehatan Indonesia 2000. Jakarta: Pusat data kesehatan; 2000.
7. Abdulsalam M, Daniel A. Diagnosis, pengobatan dan pencegahan anemia defisiensi besi. Sari Pediatri. 2002; 4:74-7.
8. Ratnadi A, Soetjiningsih. Iron status in breast-fed infants. Pediatr Indones. 2001;41:191-6.
9. Irsa L. Gangguan kognitif pada anemia defisiensi besi. Sari Pediatri. 2002;4:114-8.
10. McGregor SG, Ani C. A review of studies on the effect of iron deficiency on cognitive development in children. J Nutr. 2001;131:649S-68S.
11. Abdulsalam M. Aspek klinis dan pencegahan anemia defisiensi besi. In: Nasar SS, Agoesman S, editors. Naskah Lengkap Pendidikan Kedokteran Berkelanjutan Ilmu Kesehatan Anak FKUI XIX. 8-9 Sept. 1989. Jakarta: Balai Penerbit FKUI, 1989; p.111-9.
12. Sayogo S, Margono SS, Suryadei MA, Dilon DH, Ismid S. Studi anemia pada anak sekolah dasar. MKI. 1995;45:592-8.
13. Soemantri AG, Pollit E, Kim I. Iron deficiency anemia and educational achievement. Am J Clin Nutr. 1985: 42:1221-8.
14. Pollit E, Hathirat P, Kochabbhakdi NJ. Iron deficiency and educational achievement in Thailand. Am J Clin Nutr.

1989;50:687-97.
15. Perin EC. Chronic conditions. In: Parker S, Zuckerman B, Agustyn M, editors. Development and behavioural pediatrics. A handbook for primary care. Philadelpia-Tokyo: Lippincott, Williams & Wilkins, 2005; p.152-7.
16. Soemantri AG. Hubungan anemi kekurangan zat besi dengan konsentrasi dan prestasi belajar [Dissertation]. Semarang: Fakultas Kedokteran Universitas Diponegoro;1978.
17. Worwood M. Indicators of the iron status of populations: ferritin. In: Joint World Health Organization/Centers for Disease Control and Prevention Technical Consultation on the Assessment of Iron Status at the Population Level. Assessing the iron status of population. Geneva, 2004; p. 31-73.
18. Worwood M. Ferritin. Blood Rev. 1990;4:259-69.
19. Rogers JT, Bridges KR, Dumowicz GP, Glass J, Auron PF, Munro HN. Ferritin synthesis in response to interleukin-1. J Biol chem. 1990;265:14572-8.
20. Petterson T, Kivivuori SM, Siimes MA. Is serum transferrin receptor useful for detecting iron-deficiency in anemic patients with chronic inflammatory disease? Brit J Rheum. 1994;33:740-4.
21. van den Broek NR, Letsky EA. Etiology of anemia in pregnancy in south Malawi. Am J Clin Nutr. 2000;72:247s-56s.
22. Asobayire FS, Adou P, Davidsson L, Cook JD, Hurrell RF. Prevalence of iron deficiency with and without concurrent anemia in population groups with high prevalence of malaria and other infections: a study in Cote d'Ivoire. Am J Clin Nutr. 2001;74:776-82.
23. Pollit E. Iron deficiency and educational deficiency. Nutr Rev. 1997;55:133-40.