World Nutrition Journal | eISSN 2580-7013

ORIGINAL ARTICLE

Iron intake and its correlation to ferritin and hemoglobin level among children aged 24-36 months in Jakarta in 2020

Jessica Ferdi,[1] Saptawati Bardosono,[1] Bernie Endyarni Medise[2]

1. *Department of Nutrition, Faculty of Medicine, Universitas Indonesia, Dr. Cipto Mangunkusumo Hospital, Jakarta, Indonesia*
2. *Department of Child Health, Faculty of Medicine, Universitas Indonesia, Dr Cipto Mangunkusumo Hospital, Jakarta, Indonesia*

Received 2 January 2021
Accepted 6 January 2021

Link to DOI:
10.25220/WNJ.V05.i1.0014

Journal Website:
www.worldnutrijournal.org

Abstract

Background: Iron is essential for child's development and growth. Children's iron requirements are secured from daily food intake that might be affected by Covid-19 pandemic. This study aims to determine iron intake and its association with ferritin and hemoglobin levels as indicators of iron status among children in Jakarta.

Methods: This cross-sectional study was conducted in Kampung Melayu, Jakarta from September to October 2020. Seventy seven healthy children aged 24–36 months were taken using total population sampling method. Interviews were conducted to obtain characteristics data and iron intake using a semi-quantitative-food frequency questionnaire (SQ-FFQ). Blood tests were performed to check the levels of ferritin (controlled by hs-CRP value), and hemoglobin. Pearson's/Spearman's correlation test was performed using SPSS version 20.0.

Results: Median of iron intake was 9.6 (1.5–40,7) mg/day, in which 33.8% of subjects was below the Indonesian Recommended Dietary Allowance (RDA) recommendation. The median ferritin value was 18.1 (1.4–91.1) μg/L and the hemoglobin was 11.8 (6.6–15.2) g/dL, in which 40.3% and 27.3% subjects with iron insufficient-deficient and anemia, respectively. There were positive correlations between iron intake and ferritin ($r = 0.328$, $p = 0.002$) and iron intake and hemoglobin ($r = 0.308$, $p = 0.003$). A strong positive correlation was found between ferritin and hemoglobin ($r = 0.769$, $p < 0.001$).

Conclusions: Iron intake of children aged 24–36 months had a weak positive correlation with ferritin and hemoglobin level.

Keywords children aged 24–36 months, ferritin, hemoglobin, iron intake, Jakarta

Introduction

Iron is an essential nutrient needed for the growth and development of children. Iron in the body is used for various cellular processes, including the formation of red blood cells, muscle cells, gene transcription, and nerve and brain development.[1] Iron deficiency persists to be the most common nutritional problem in children.[1] This can be caused by low iron intake, poor food quality and eating habits, gastrointestinal disease or parasite infection.[2] A continuous lack of iron intake can lead to a decrease in body's iron stores, iron deficiency erythropoiesis, to iron deficiency anemia.

The body's iron can be determined through a bone marrow biopsy examination. However, this is considered to be invasive and not commonly done. Blood ferritin test is the most frequent examination to determine body iron store.[3] Ferritin is an acute phase protein whose levels increase when inflammation occurs.[4] Inflammation can be assessed

Corresponding author:
dr. Jessica Ferdi
Department of Nutrition, Faculty of Medicine, Universitas Indonesia
Jl. Salemba Raya no.6, Central Jakarta, Indonesia
Email: jess.ferdi@gmail.com

by examining high sensitivity-C reactive protein (hs-CRP).[5] The CRP levels ≥ 10 mg/L are associated with infection.[6] In children under 5 years of age without infection, ferritin levels < 12 μg/L indicates insufficient body iron store. Decrease in ferritin levels generally does not show symptoms, hence rarely realized. If the decrease in ferritin levels continues, a decrease in hemoglobin levels may occur, leading to anemia (hemoglobin levels < 11 g/dL)[7].

In children, fulfillment of iron requirements is secured from daily intake or supplementation. Iron is found in red meat, fish, poultry, vegetable sources, and iron fortification products in which their availability might be affected due to Covid-19 pandemic. Provision of adequate iron-rich intake is expected to meet the body's iron requirements. From the Indonesian RDA, the recommended iron intake for children aged 24–36 months is 7 mg/day.[8] Herawati et al. found that 50.5% of Indonesian children under five years of age had iron intake below 77% Indonesian RDA.[9] The rapid growth of children occurs in the first 2 years of life, but high iron requirements are still needed until the age of 3 years.[10] In Europe, even though average iron intake in children is close to the daily recommendation, there is still high levels of insufficient in intake and iron levels.[11] In Indonesia, Herawati et al found 36.8% of children aged 24–35 months had less than required ferritin and hemoglobin levels.[9] Therefore, it is important to pay attention to iron intake at this age bracket to support optimal child development as a good provision before entering the preschool age.

The Covid-19 pandemic that occurred in 2020 caused economic impacts, including reduced economic growth and an increase in the unemployment rate. There are 29.12 million people of working age who have been affected by Covid-19.[12] This economic impact can affect the purchasing power and fulfillment of children's iron needs. This study aims to determine iron intake and its association with ferritin and hemoglobin levels in children aged 24–36 months in Jakarta.

Methods

This cross-sectional study was carried out during the Covid-19 pandemic, from September to October 2020 in Kampung Melayu Sub-district, Jakarta. This place was chosen because it was the only limited resources eligible that provided permission to do data collection due to the Covid-19 pandemic. This study was approved by the Health Research Ethics Committee of Faculty of Medicine, Universitas Indonesia(No. 441/UN2.F1/ETIK/PPM.00.02/2020, protocol number 20-04-0460).

Subjects

The study subjects were healthy boys and girls aged 24–36 months, with their parents provided permission to participate in the study. Subject selection was carried out by total population sampling. The subject's parents were explained about the purpose, benefits and the examinations to be carried out. Parents who agreed to take part in the research were asked to sign a consent form. Children with acute infections, fever, cough, colds, congenital diseases and syndromes, epilepsy, cerebral palsy, and mental disorders were excluded from the study. Of the total 87 subjects, 5 subjects did not complete the study procedure, 2 blood samples were lysis, and there were 3 subjects with elevated hs-CRP level (≥ 10 mg/L), therefore only 77 samples were furthered analyzed.

Characteristic data

Data on subjects' characteristics include: age, gender, gestational age, birth weight, maternal education, and family income were obtained from interviews. Maternal education was categorized into high (high school education and above) and low (below high school education). Family income was categorized based on the value of minimum wage (UMP) DKI Jakarta 2020 (Rp. 4,276,350) to be more or equal to the UMP and less than the UMP.

Iron intake and anthropometric measurement

The assessment of iron intake was taken using a semi quantitative-food frequency questionnaire (SQ-FFQ). Interviews were conducted to determine the subjects' iron intake during the last 1 month. Interviews were conducted using a food photo book. Anthropometric measurement includes body weight and height. The subjects' body weight was measured using the SECA digital scale, to an accuracy of 0.1

kg. The subjects' clothes and accessories were removed or only wore minimal clothing and the subjects stood on the scale. The subjects' height was measured using a SECA stadiometer with an accuracy of 0.1 cm. The subjects looked forward at the Frankfort horizontal plane, the heel, buttocks and back of the head touching the stadiometer. Each measurement was carried out twice and the average value was taken. Nutritional status was determined based on the Z-score weight/height in the WHO 2006 growth chart.[13]

Laboratory examination

Blood tests were performed to check the levels of ferritin, hemoglobin, and hs-CRP. The blood tests were conducted in collaboration with Prodia Laboratory. The subjects' blood was drawn in the Kampung Melayu Sub-district office by laboratory personnel. Prior to drawing blood, the subjects' cubiti area was disinfected with an alcohol swab. A total of 6 ml of blood was drawn in the cubiti area by laboratory personnel. Then the blood samples were taken to Prodia Laboratory for analysis. Ferritin examination was performed with the immunochemiluminescent method[14] using Immulite 2000, hemoglobin examination was performed with the cyanmethemoglobin-oxyhemoglobin method[15] using XN-series (Sysmex), and hs-CRP was performed with the immunoturbidimetric method[6] using the Architect C System.

Data analysis

Data were analyzed using IBM Statistical Package for the Social Sciences (SPSS) version 20.0. The normality of the data distribution was determined by the Kolmogorov Smirnov test. The data distribution was considered normal when the p value > 0.05. Categorical data were presented in the form of a frequency distribution (n, %). Continuous data were presented in the form of median (minimum-maximum). The Pearson's /Spearman test was used to determine the correlation of iron intake with ferritin levels and hemoglobin levels. The correlations were considered significant if the p value ≤ 0.05. Nutrisurvey 2007 was used to perform analysis of iron intake.

Results

From the 77 subjects, the median age was 30 (24–36) months. The majority of subjects had normal nutritional status and family income below UMP DKI Jakarta 2020. Data on subjects' characteristics can be seen in **Table 1**.

In this study, the median value of iron intake was 9.6 (1.5–40.7) mg/day. When compared with the 2019 Indonesian RDA adequacy, it was found that 33.8% of the subjects had insufficient iron intake. The results can be seen in **Table 2**. The median (minimum-maximum) ferritin value was 18.1 (1.4–91.1) μg/L and hemoglobin was 11.8 (6.6–15.2) g/dL. When compared with the cut value of ferritin (< 12 μg/L), there were 40.3% subjects with insufficient ferritin values. There were 27.3% subjects with insufficient hemoglobin (< 11g/dL) or anemia. The adequacy of ferritin and hemoglobin can be seen in **Table 3**.

The correlation between iron intake and ferritin levels and hemoglobin levels can be seen in **Table 4**. There were a weak positive correlation between iron intake and ferritin levels (r = 0.328, p = 0.002) and iron intake with hemoglobin levels (r = 0.308, p = 0.003). There was a strong positive correlation between ferritin and hemoglobin levels (r = 0.769, p < 0.001).

Discussion

This study showed a positive correlation between iron intake and ferritin levels (r = 0.328, p = 0.002) and iron intake with hemoglobin levels (r = 0.308, p = 0.003). This result is similar to the study of Herawati et al,[9] which found a positive correlation between the adequacy of iron intake and hemoglobin level in Indonesian children (r = 0.219; p = 0.041). This indicates that the amount of iron intake plays a role in the formation of ferritin and hemoglobin. This is similar to a study by Thompson et al that found an increase in ferritin and hemoglobin in children aged 2–5 years who received iron supplementation.[16] There was a strong positive correlation between ferritin and hemoglobin levels (r = 0.769, p < 0.001). This indicates the needs for adequate body iron store to support optimal hemoglobin formation. This is similar to the study of Herawati et al which obtained a positive correlation between ferritin and hemoglobin concentrations ($r = 0.447$, $p < 0.05$).[9]

Iron is required for various processes in the body, such as deoxyribonucleic acid (DNA) biosynthesis, oxygen transport, energy metabolism, the formation of red blood cells, muscle cells, and brain development[1] hence when iron needs are not met, it will affect optimal child growth and development. In children, iron intake is secured from daily food. Based on the Indonesian RDA, the recommendation of iron consumption in children aged 24–36 months is 7 mg/day.[8] It is hoped that iron needs can be fulfilled from a variety of foods that are rich in iron.[1] Iron is obtained from food sources of heme and non-heme iron. Sources of heme iron come from red meat, poultry, and fish. Meanwhile, non-heme iron sources come from vegetable sources and fortification products. Most foods are sources of non-heme iron. However, the absorption of non-heme iron sources is lower, namely by 2–20% compared to heme iron sources of 15–35%.[17] Although the median iron intake of subjects in this study (9.6 mg/day) was higher than the recommendation in Indonesian RDA, however one-third of subjects did not have sufficient iron intake. Continuous lack of iron intake will cause a decrease in the body's iron reserves. Reduced body iron reserves can be detected from low serum ferritin levels, which can lead to decreased hemoglobin levels (anemia).[3] A study by Timmer et al[18] in the Netherlands on adult blood donors, found that higher hemoglobin levels were associated with a high intake of heme sources and a low intake of non-heme sources.[18] The similar thing was found in a study by Cox et al[19] on children aged 12–36 months in Canada, who found that consumption of heme iron from red meat reduces the risk of iron deficiency.

In this study, 40.3% of the subjects had insufficient ferritin levels. The percentage of ferritin insufficiency in this study was higher than the study by Herawati et al in children aged 24–35 months in Indonesia, namely 36.8%.[9] In this study, hemoglobin insufficiency was present in 27.3% of subjects. This result is lower than the study by Herawati et al, namely 36.8%.[9] If the children's ferritin level was not corrected, the hemoglobin insufficiency will also increase.

The balance of body's iron is regulated by absorption and transportation systems. Iron from food will be absorbed in the small intestine, stored in ferritin, used for cell needs, and brought into the circulation to meet the needs of the body's cells.[20] The amount of iron that is absorbed depends on the physiological needs and the body's iron reserves.[21] When the body's iron reserves are low, the absorption in the intestine will increase. Iron that is not used will be stored in ferritin. Most of the body's iron is found in erythrocytes, as part of the heme in hemoglobin.[22] When erythrocytes are senescent, they were recycled by macrophages. The degraded heme releases iron, biliverdin, and carbon monoxide. Iron will be transported to the cytoplasm, stored in ferritin as the body' iron reserves, used for cellular process, or transported out by ferroportin.[22] Maintaining iron intake is important to support the ferritin and hemoglobin adequacy.

There were some limitations of this study. It was carried out during the Covid-19 pandemic, thus resulting in limited time and available resources in the field. In addition, the parents of the prospective subject were also afraid to participate to avoid meeting activities during the Covid-19 pandemic. Limitations of the study included the possibility of memory bias in assessing the iron intake of children with the SQ-FFQ, even though food photo books had been used to reduce the bias.

Conclusion

From this study it can be concluded that iron intake had a positive correlation with ferritin and hemoglobin levels. One third of the subjects still had iron intake below the daily requirement. Iron is needed in the development and growth of children aged 24–36 months, thus it is important to pay attention to the adequacy of iron intake. By educating mothers about iron sources in food related to child feeding, it is hoped that the iron intake will be increased, thus increase the optimal iron status i.e. ferritin and hemoglobin

Table 1. Subjects' characteristics

Characteristics	Results
Age (months)	30 (24–36)†
Gestational age (weeks)	39 (32–42)†
Birth weight (grams)	2985 (1200–3900)†
Gender, n (%)	
Male	41 (53.2)
Female	36 (46.8)
Nutritional status, n (%)	
Obese	3 (3.9)
Overweight	1 (1.3)
Normal	66 (85.7)
Wasted	7 (9.1)
Severely wasted	-
Maternal education, n (%)	
High	45 (58.4)
Low	32 (41.6)
Family income, n (%)	
≥ UMP	19 (24.7)
< UMP	58 (75.3)

†: median (minimum-maximum)

Table 2. Subjects' iron intake

Variables	Results
Iron intake (median; minimum-maximum)	9.6 (1.5–40.7)
Adequacy of iron intake, n (%)	
Sufficient	51 (66.2)
Insufficient	26 (33.8)

Table 3. Subjects' adequacy of ferritin and hemoglobin levels

Variables	Results
Ferritin adequacy, n (%)	
Sufficient	46 (59.7)
Insufficient	31 (40.3)
Hemoglobin adequacy, n (%)	
Sufficient	56 (72.7)
Insufficient	21 (27.3)

Table 4. Correlation of iron intake with ferritin and hemoglobin levels

	Ferritin		Hemoglobin	
Nutrient	r	p (1-tailed)	r	p (1-tailed)
Iron intake	0.328	0,002*	0.308	0,003*

*: statistically significant

Conflict of Interest

Authors declared no conflict of interest regarding this article.

Acknowledgment

We would like to convey our gratitude to all those who helped in the course of this study, including but not limited to, the study subjects, *Puskesmas* Kampung Melayu and its sub-district office.

Open Access

References

1. Cerami C. Iron nutriture of the fetus, neonate, infant, and child. Ann Nutr Metab. 2017;71(suppl 3):8–14. DOI: 10.1159/000481447.
2. Ozdemir N. Iron deficiency anemia from diagnosis to treatment in children. Turk Pediatri Ars. 2015;50(1):11–9. DOI: 10.5152/tpa.2015.2337.
3. Pfeiffer CM, Looker AC. Laboratory methodologies for indicators of iron status: strengths, limitations, and analytical challenges. Am J Clin Nutr. 2017;106:1606–20. DOI: 10.3945/ajcn.117.155887.
4. WHO. Serum ferritin concentrations for assessment of iron status and iron deficiency in populations. Vitamin and Mineral Nutrition Information System. Geneva: World Health Organization; 2011.
5. Nehring SM, Patel BC. C reactive protein [Internet]. Treasure Island: StatPearls Publishing; 2019 [cited 2019 Oct 15]. Available from https://www.ncbi.nlm.nih.gov/books/NBK441843/
6. WHO. C-reactive protein concentrations as a marker of inflammation or infection for interpreting biomarkers of micronutrient status. Geneva: World Health Organization; 2014.
7. WHO. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Geneva: World Health Organization; 2011.
8. Kementerian Kesehatan RI. *Peraturan Menteri Kesehatan Republik Indonesia Angka kecukupan gizi yang dianjurkan untuk masyarakat Indonesia*. 2019
9. Herawati AN, Palupi NS, Andarwulan N, Efriwati. *Kontribusi asupan zat besi dan vitamin c terhadap status anemia gizi besi pada balita Indonesia*. Peneliti Gizi dan Makanan. 2018;41(2):65–76.
10. Cusick S, Georgieff MK. The first 1,000 days of life: the brain's window of opportunity [Internet]. UNICEF; [cited 2020 Mar 6]. Available from https://www.unicef-irc.org/article/958-the-first-1000-days-of-life-the-brains-window-of-opportunity.html
11. Eussen S, Alles M, Uijterschout L, Brus F, van der Horst-Graat J. Iron intake and status of children aged 6–36 months in Europe: a systematic review. Ann Nutr Metab. 2015;66:80–92. DOI: 10.1159/000371357.
12. Badan Pusat Statistik. *Keadaan Ketenagakerjaan Indonesia Agustus 2020* [Internet]. Jakarta: Badan Pusat Statistik; 2020 [cited 2020 Dec 10]. Available from: https://www.bps.go.id/website/images/Keadaan-Ketenagakerjaan-Indonesia-Agustus-2020-ind.jpg
13. WHO. Child growth standards weight-for-length/height [Internet]. Geneva: World Health Organization; 2006 [cited 2020 Dec 1]. Available from https://www.who.int/tools/child-growth-standards/standards/weight-for-length-height
14. Garcia-Casal MN, Pena-Rosas JP, Urrechaga E, Escanero JF, Huo J, Martinez RX, et al. Performance and comparability of laboratory methods for measuring ferritin concentrations in human serum or plasma: a systematic review and meta-analysis. PLoS ONE. 2018;13(5): e0196576. DOI: 10.1371/journal.pone.0196576.
15. Gibson RS. Assessment of iron status. In: Principles of nutritional assessment. 2nd ed. New York: Oxford; 2005. p. 443–76.
16. Thompson J, Biggs B-A, Pasricha S-R. Effects of daily iron supplementation in 2- to 5-year-old children: systematic review and meta-analysis. Pediatrics. 2013 Apr 1;131(4). DOI: 10.1542/peds.2012-2256.
17. Wessling-Resnick M. Iron. In: Ross AC, Caballero B, Cousins RJ, Tucker KL, Ziegler TR, editors. Modern nutrition in health and disease. 11th ed. Baltimore: Lippincott Williams & Wilkins; 2014. p. 176–88.
18. Timmer TC, de Groot R, Rijnhart JJM, Lakerveld J, Brug J, Perenboom CWM, et al. Dietary intake of heme iron is associated with ferritin and hemoglobin levels in Dutch blood donors: Results from Donor InSight. Haematologica. 2020 Oct 1;105(10):2400-6. DOI: 10.3324/haematol.2019.229450.
19. Cox KA, Parkin PC, Anderson LN, Chen Y, Birken CS, Maguire JL, et al. Association Between Meat and Meat-Alternative Consumption and Iron Stores in Early Childhood. Acad Pediatr. 2016 Nov 1;16(8):783–91. DOI: 10.1016/j.acap.2016.01.003.
20. Domellof M. Iron requirements, absorption and metabolism in infancy and childhood. Curr Opin Clin Nutr Metab Care. 2007 May;10(3):329–35. DOI: 10.1097/MCO.0b013e3280523aaf.
21. Wallace DF. The regulation of iron absorption and homeostasis. Clin Biochem Rev. 2016 May;37(2):51–62.

22. Cassat JE, Skaar EP. Iron in infection and immunity. Cell Host Microbe. 2013 May;13(5): 509–19. DOI: 10.1016/j.chom.2013.04.010.