folia medica

Folia Medica 64(3):437-442
DOI: 10.3897/folmed.64.e64593

Original Article

Daily Iron Intake and BMI for Age but Not for Daily Tannin Intake Increase Hemoglobin Levels in Young Females at Karanganyar Regency, Central Java, Indonesia

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Received: 19 Feb 2021 ♦ **Accepted:** 20 Apr 2021 ♦ **Published:** 30 June 2022

Citation: Ilmiyati L, Indarto D, Wasita B. Daily iron intake and BMI for age but not for daily tannin intake increase hemoglobin levels in young females at Karanganyar Regency, Central Java, Indonesia. Folia Med (Plovdiv) 2022;64(3):437-442. doi: 10.3897/folmed.64.e64593.

Abstract

Introduction: Prevalence of anemia among young women in Indonesia has been seen to increase in the last five years. This situation indicates that this nutritional disorder looks like an iceberg phenomenon. Daily consumption of vegetables containing foods is recommended for prevention of non-communicable diseases including anemia. These foods contain not only ferric ions but also other natural compounds.

Aim: To analyse the relationship of daily intake of micronutrients and polyphenols with hemoglobin levels in young females.

Materials and methods: This cross-sectional study recruited 117 young females who studied in six senior high schools in Karanganyar Regency, Central Java; they were selected using a purposive sampling. Data of micronutrients and polyphenols intake were collected using the Semi Quantitative-Food Frequency questionnaire. Blood samples from lower arm veins were used for hemoglobin measurements in a hematology analyser. The collected data were analysed using the Rank Spearman and multiple regression linear tests to evaluate the relationship of micronutrients and polyphenols intake with the hemoglobin levels.

Results: The prevalence of anemia was 17.1% among 20/117 young females. Higher dietary intake of iron (b=0.043; $p<0.001$) and higher BMI for age (b=0.246; $p=0.025$) increased the Hb levels while higher dietary intake of tannin (b=−0.003; $p=0.009$) decreased them.

Conclusions: Dietary intake of iron and BMI for age are related to the hemoglobin levels but tannin intake is inversely related to these levels in young females. Higher iron intake from vegetable resources should be taken into account for anemia reduction in young females due to the presence of tannins.

Keywords

anemia, micronutrients, polyphenols, young females

INTRODUCTION

Anemia remains a nutritional problem around the world, which looks like an iceberg phenomenon and is primarily caused by iron deficiency.[1] In 2018, the morbidity rate of anemia in Indonesia increased by 48.9%, which mostly affected female adolescents and young adults (15-24 years old).[2] For a long term period, anemia in young adults who get pregnant will have bad impacts on their health and fetus such as preeclampsia, bleeding, low birth weight, small-for-gestational-age fetus, and premature birth.[3,4]

Daily vegetable consumption is recommended for prevention of non-communicable diseases (NCDs)[5] including anemia. Vegetables are not only an iron source but also other natural sources that play an important role in iron metabolism such as vitamin A, vitamin E, and polyphenols.[6,7] Vitamin A can increase iron absorption in the small intestine by mobilization of iron-containing ferritin to all body tissues.[8] Apart from vitamin A, daily intake of vitamin E functions physiologically as an exogenous antioxidant and oxidant scavenger in red blood cells for preventing lipid peroxidation by free radicals in cell membranes and organelles.[9,10] A randomized control trial conducted in Colorado showed that serum vitamin E and iron consumptions can increase serum ferritin levels, back to normal condition.[11] Beside micronutrients, vegetables also have a variety of polyphenols like tannins and phytate that are widely distributed in all parts of vegetables. Tannins interact with iron to make complex compounds which reduce iron availability and are with low absorption in the small intestine.[12] Two other chemical compounds (phytate and oxalic acids) are also recognized as natural inhibitors of iron absorption. From epidemiological and experimental studies, the roles of those micronutrients and polyphenols in anemia disorder have indicated contradictory results.[13,14]

AIM

This study aimed to assess the relationship of dietary intake of micronutrients and polyphenols by measuring the Hb levels in young females.

MATERIALS AND METHODS

Research participants

One hundred and seventeen young females who studied at high and vocational schools in Colomadu, Jumapolo and Matesih districts participated in this study and were selected using a purposive sampling. We recruited young females who were in grade X and XI from those schools, aged 14-18 years old and lived in those districts at least 6 months whilst we excluded those who had menstruation and had blood disorders such as thalassemia, worm infection and malaria. The study protocol was approved by the Health Research Ethic Committee of Dr. Moewardi General Hospital, Surakarta (No. 102/I/HREC/2020) and all of study participants signed an informed consent before the research began.

Study design and data collection

The present study has a cross-sectional design; it was conducted from February to April, 2020. The sample size was calculated using a formula based on the prevalence of anemia in Karanganyar regency (data not shown). Venous blood samples of research participants were used to determine the Hb levels by using a hematology analyser at the Clinical Laboratories in Surakarta City, Jumapolo, or Matesih Community Health Centres. Young women with Hb levels higher or equal to 12 g/dL were categorized as having no anemia.[15] Nutritional data of micronutrients, tannin, phytate, oxalate, and confounding factors such as protein and iron were collected using the semi-quantitative food frequency questionnaire (SQ FFQ). Calculated values of vitamin A, vitamin E, iron, and protein intake were compared with nutrient intake values of Indonesian Recommended Dietary Allowance (RDA) (data not shown). Furthermore, the body mass index (BMI) for age was determined using the WHO Z-score table and then the participants were classified as either thin (−3 SD to <−2 SD), normal (−2 SD to +1 SD), overweight (+1 SD to +2 SD), or obese (>+2 SD) according to their respective index.

Statistical analysis

SPSS v. 21 was used to analyse all collected data. Mean ± standard deviation (SD) represented numeric data whereas frequency and percentage represented categorical data. Before performing the correlation test, data normality was assessed using the Kolmogorov-Smirnov test. Independent Student *t* and Mann-Whitney tests were used to compare the non-anemia with anemia groups **(Tables 1, 2)** whilst the Rank Spearman test was used to examine the correlations of independent variables and confounding factors with Hb levels **(Table 3)**. The multiple linear regression test was used to evaluate further correlations of those variables with Hb levels **(Table 4)**. A p value less than 0.05 was considered statistically significant.

RESULTS

Table 1 shows the general characteristics of research participants. Anemia was found in 17.1% (20/117) of the young women. The average of age, menstruation length, and BMI for age in non-anemic young females was slightly lower than that of anemic young females while non-anemic young females had a higher average of physical activity and parent income compared to anemic young females. However, the average BMI for age in both groups was normal weight although the non-anemia group had a significantly

Table 1. Baseline characteristics of the young females who participated in this study

Variable	Non-anemia (n=97)		Anemia (n=20)		
	Min-Max	Mean ± SD	Min-Max	Mean ± SD	*P*
Age (years)	14-18	15.7±0.74	15-17	16±0.64	0.147
Menstruation (days)	4-9	6.27±1.1	4-9	6.65±1.18	0.139
Physical activity (METs)	328.5-5992	1674.2±1423.1	500-2933	995±701.5	0.161
Parents income (IDR million)	0.45-5	1.9314±1.179	0.5-3	1.545±0.66	0.343
BMI for age (z-score)**	-2.67 -2.69	-0.07±1.16	-2.1-2.5	-1.04±1.27	0.001**

IDR: Indonesian rupiah; * The level of statistical significance was set at $p<0.05$; All data were analysed using the Mann-Whitney test except BMI for age with independent Student *t* test**.

higher average BMI than the anemia group. In addition, parents income in the non-anemia group had an average close to the minimum wage in Karanganyar Regency (IDR 1.989 million).[16]

Table 2 shows the average daily consumption of nutrients and polyphenols in the non-anemia and anemia groups. As can be seen, the average vitamin A, vitamin E, tannin, oxalate, phytate, and protein consumption was higher in the anemia group compared with the non-anemia group but a higher daily intake of Fe and vitamin C was observed in the non-anemia group. In addition, only the Fe daily intake reached significance ($p<0.001$).

To assess the independent correlation of all daily dietary intake and BMI for age with Hb levels, the Spearman test was performed. In general, all variables indicated positive correlations with Hb levels except for tannins, oxalates, and phytates (**Table 3**). Furthermore, Fe and vitamin C daily intake had a significant correlation with Hb levels and the higher correlation was Fe daily intake ($r=0.40$; $p<0.001$).

The next statistical analysis used the multiple linear regression test for evaluating all variables, which together influenced Hb levels in young females **(Table 4)**. Fe daily

Table 3. The relationship of independent variables and confounding factors with Hb levels

Variable	r	*P*
Daily Food Intake		
Fe (mg/day)	0.40	<0.001*
Vitamin A (RE/day)	0.01	0.289
Vitamin E (mcg/day)	0.01	0.900
Tannin (mg/day)	−0.11	0.234
Oxalate (g/day)	−0.07	0.442
Phytate (mg/day)	−0.10	0.273
Confounding factor		
Protein intake (g/day)	0.07	0.45
Vitamin C (mg/day)	0.20	0.033
BMI for age (z-score)	0.15	0.094

* The level of statistical significance was set at $p<0.05$

Table 2. The average of daily dietary intake in anemic and non anemic young females

Variable	Non Anemia (n=97)		Anemia (n=20)		
	Min-Max	Mean ± SD	Min-Max	Mean ± SD	*P*
Daily Food Intake					
Fe (mg/day)**	4.11-85.96	26.06±14.24	4.92-42.12	13.05±8.84	<0.001*
Vitamin A (RE/day)	114.54-1.719.6	628.8±396.5	100.6-1,492.2	652.8±353	0.393
Vitamin E (mcg/day)	0.76-80.43	12.84±12.42	2.01-51.94	12.97±12.01	0.257
Tannin (mg/day)	107.03-489.8	205.5±84.9	110.8-896.1	268±174.9	0.092
Oxalate (g/day)	0.01-2.81	0.48±0.15	0.07-6.83	2±0.813	0.379
Phytate (mg/day)	23.62-1,708.8	364.4±346.4	10.08-1.364.84	394.38±347.8	0.558
Confounding factor					
Protein (g/day)	20.1-277.9	83.8±51.8	11.2-337.9	84±75.7	0.664
Vitamin C (mg/day)**	37.02-385.69	189.9±97.7	52.29-342.34	167.5±88.9	0.334

RE: retinol equivalent; * The level of statistical significance was set at $p<0.05$; All data were analysed using the Mann-Whitney test except Fe and vitamin C intake with the independent Student *t* test**.

Table 4. Multivariate analysis of independent variables and confounding factors with Hb levels

Variable	b	T	*p*	95% CI	β
Constant	12.419	28.117	0.000	11.54-13.29	
Fe intake (mg/day)	0.043	4.482	<0.001*	0.024-0.062	0.381
Tannin intake (mg/day)	-0.003	-2.673	0.009*	-0.006-0.001	-0.230
Vitamin C (mg/day)	0.002	1.484	0.141	-0.001-0.005	0.131
BMI for age (z-score)	0.246	2.278	0.025*	0.032-0.46	0.188

b: unstandardized coefficient; β: standardized coefficient; *The level of statistical significance was set at $p<0.05$

intake was significantly related to Hb level (b=0.043; $p<0.001$) after adjustment with confounding factors. However, this relationship was weaker than the correlation between BMI for age as the confounding factor and Hb level (b=0.246; $p=0.025$). This study also showed that there was a negative correlation of tannin daily intake with the Hb levels which reached significance (b=−0.003; $p=0.009$).

DISCUSSION

In this study, we found that 17.1% of the young females in Karanganyar regency had anemia. It clearly indicated that daily Fe and tannin intake influenced the Hb levels with opposite correlation and BMI for age also influenced the Hb levels. The results in this study are in line with a previous study which found a significant relationship between iron intake and adolescent Hb levels.[17] Theoretically, iron is a major component of red blood cell formation with nearly two-thirds of it found in hemoglobin.[18] This study also shows that there is a negative correlation of tannin daily intake with Hb levels. This result indicated that the increased tannin consumption was followed by a decrease of the Hb levels in the young women in the study. This is consistent with the theory that tannins interact with iron to make complex compounds which reduce iron availability resulting in its low absorption in the small intestine. All vegetables contain different tannin levels which belong to polyphenols. The inhibitory effect of polyphenols on iron absorption has been widely reported[12] but the reduction in iron absorption depends on each structure of polyphenols.[19] Moreover, vitamin C daily intake in this study had a positive correlation with the Hb level but it failed to reach significance. This is probably due to the adequate daily intake of vitamin C in young females in the anemia and non-anemia groups but unable to reduce the inhibitory effect of tannins derived from vegetables and fruits.[20] However, the important role of phytate and oxalate as Fe inhibitors can be ignored in this study since their correlations were weak and not significant to Hb levels.

The Hb levels in young females were also influenced by BMI for age (z-score). Our data indicated that the mean BMI for age of young females in the non-anemia group was higher than the mean BMI for age of young females in the anemia group **(Table 1)**. It means that young females in the non-anemia group had better nutritional status which denotes the balance state of nutrient intake, nutrient requirement, and human body metabolism. Altogether, Fe, tannin daily intake, and BMI for age in young females in Karanganyar regency significantly influence the Hb levels by 24.1%.

CONCLUSIONS

Daily iron and tannin consumptions are differently related to Hb level in young females at Karanganyar Regency. Furthermore, BMI for age has a stronger relationship to Hb levels than daily iron and tannin consumptions although this factor is not the main research variable. These findings confirm that daily iron intake plays a vital role for maintaining the hematological status of young females. However, we used just a limited number of research participants to generate these data, which do not represent general Indonesian population. In addition, further studies are needed using a combination of food questionnaire, food records, and biological markers to investigate all factors that contribute to Hb production.

Acknowledgments

The authors would like to thank the principals and their staff of higher vocational schools in Colomadu, Jumapolo and Matesih districts for giving permission and the Health Laboratories in Surakarta City, Jumapolo, or Matesih Community Health Center for the hemoglobin levels assessment.

Funding

This study was partially funded by the Indonesian Ministry of Research and Technology in 2020 (065/SP2H/LT/DRPM/2020).

REFERENCES

1. World Health Organization. The Global prevalence of anaemia in 2011. Geneva, Switzerland: World Health Organization; 2015. Available from: https://apps.who.int/iris/bitstream/han-

dle/10665/177094/9789241564960_eng.pdf;jsessionid=42C5F998CBB86A80EE6230F8C73CB515?sequence=1 (Accessed on 23 July 2020).
2. The Indonesian Ministry of National Development. The Consolidated Report on Indonesia Health Sector Review 2018, 2019. Available from: https://www.unicef.org/indonesia/media/621/file/Health%20Sector%20Review%202019-ENG.pdf%20.pdf. (Accessed on 03 February 2021).
3. Abu-Ouf NM, Jan MM. The impact of maternal iron deficiency and iron deficiency anemia on child's health. Saudi Med J 2015; 36(2):146–9.
4. Mahmood T, Rehman AU, Tserenpil G, et al. The association between iron-deficiency anemia and adverse pregnancy outcomes: a retrospective report from Pakistan. Cureus 2019; 11(10):1–10.
5. Branca F, Lartey A, Oenema S, et al. Transforming the food system to fight non-communicable diseases. BMJ 2019; 364:1–7.
6. Zielińska-Dawidziak M. Plant ferritin - a source of iron to prevent its deficiency. Nutrients 2015; 7(2):1184–201.
7. Chacha JS, Laswai HS. Micronutrients potential of underutilized vegetables and their role in fighting hidden hunger. Int J Food Sci 2020; 2020:1–5.
8. Hurrell R, Egli I. Iron bioavailability and dietary reference values. Am J Clin Nutr 2010; 91:1461–7.
9. Marar T. Amelioration of glucose induced hemolysis of human erythrocytes by vitamin E. Chem Biol Interact 2011; 193(2):149–53.
10. Kuhn V, Diederich L, Keller TCS, et al. Red blood cell function and dysfunction: redox regulation, nitric oxide metabolism, anemia. Antioxidants Redox Signal 2017; 26(13):718–42.
11. Tang M, Frank DN, Sherlock L, et al. Effect of vitamin E with therapeutic iron supplementation. J Pediatr Gastroenterol Nutr 2017; 63(3):379–85.
12. Delimont NM, Haub MD, Lindshield BL. The impact of tannin consumption on iron bioavailability and status: a narrative review. Curr Dev Nutr 2017; 1(2):1–12.
13. Citelli M, Bittencourt LL, Da Silva SV, et al. Vitamin A modulates the expression of genes involved in iron bioavailability. Biol Trace Elem Res 2012; 149(1):64–70.
14. Petry N, Egli I, Campion B, et al. Genetic reduction of phytate in common bean (Phaseolus vulgaris L.) seeds increases iron absorption in young women. J Nutr 2013; 143(8):1219–24.
15. Freeman AM, Rai M, Morando DW. Anemia screening. Treasure Island (FL): StatPearls Publishing. 2020. Available from: https://www.ncbi.nlm.nih.gov/books/NBK499905/ (Accessed on 22 January 2021).
16. Pramono A. The role of the Central Java Provincial Wage Council in determining Regency/City minimum wages in 2020. UNTAG Law Rev 2020; 4(1):58–68.
17. Siallagan D, Swamilaksita PD, Angkasa D. The effect of iron, vitamin A, vitamin B12, and vitamin C intake on hemoglobin levels in vegetarian adolescents. J Gizi Klin Indones 2016; 13(2):67–74.
18. Abbaspour N, Hurrell R, Kelishadi R. Review on iron and its importance for human health. J Res Med Sci 2014; 19(2):164–74.
19. Petry N, Egli I, Zeder C, et al. Polyphenols and phytic acid contribute to the low iron bioavailability from common beans in young women. J Nutr 2010; 140(11):1977–82.
20. Jaramillo Á, Briones L, Andrews M, et al. Effect of phytic acid, tannic acid and pectin on fasting iron bioavailability both in the presence and absence of calcium. J Trace Elem Med Biol 2015; 30:112–7.

Ежедневное потребление железа и ИМТ в зависимости от возраста, но не для суточного потребления танина повышают уровень гемоглобина у молодых женщин в Каранганьяр Ридженси, Центральная Ява, Индонезия

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Дата получения: 19 февраля 2021 ♦ **Дата приемки:** 20 апреля 2021 ♦ **Дата публикации:** 30 июня 2022

Образец цитирования: Ilmiyati L, Indarto D, Wasita B. Daily iron intake and BMI for age but not for daily tannin intake increase hemoglobin levels in young females at Karanganyar Regency, Central Java, Indonesia. Folia Med (Plovdiv) 2022;64(3):437-442. doi: 10.3897/folmed.64.e64593.

Резюме

Введение: За последние пять лет наблюдается рост распространённости анемии среди молодых женщин в Индонезии. Эта ситуация указывает на то, что это расстройство питания выглядит как феномен айсберга. Ежедневное употребление блюд, содержащих овощи, рекомендуется для профилактики неинфекционных заболеваний, в том числе анемии. Эти продукты содержат не только ионы железа, но и другие природные соединения.

Цель: Проанализировать взаимосвязь суточного потребления микроэлементов и полифенолов с уровнем гемоглобина у молодых женщин.

Материалы и методы: В этом поперечном исследовании приняли участие 117 молодых женщин, которые учились в шести старших классах средней школы в Каранганьяр Ридженси, Центральная Ява; они были отобраны с помощью целенаправленной выборки. Данные о потреблении микронутриентов и полифенолов были собраны с использованием опросника Semi Quantitative-Food Frequency. Образцы крови из вен нижних конечностей использовали для измерения гемоглобина в гематологическом анализаторе. Собранные данные были проанализированы с использованием теста Ранка Спирмена и множественных линейных регрессионных тестов для оценки взаимосвязи потребления микроэлементов и полифенолов с уровнями гемоглобина.

Результаты: Распространённость анемии составила 17.1% среди 20/117 молодых женщин. Более высокое потребление железа с пищей (b=0.043; p<0.001) и более высокий ИМТ для данного возраста (b=0.246; p=0.025) повышали уровни гемоглобина, в то время как более высокое потребление танина с пищей (b=-0.003; p=0.009) снижало их.

Заключение: Потребление железа с пищей и ИМТ в зависимости от возраста связаны с уровнями гемоглобина, но потребление танинов обратно пропорционально этим уровням у молодых женщин. Следует принимать во внимание более высокое потребление железа из растительных ресурсов для снижения анемии у молодых женщин из-за присутствия дубильных веществ.

Ключевые слова

анемия, микронутриенты, полифенолы, молодые женщины