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Effects of Nutritional Education and Iron Supplementation on Iron Nutrition and Anemia of Middle School Girls

Soon-Myung Hong† and Hye-Jin Hwang[1]

Department of Food and Nutrition, University of Ulsan, Ulsan 680-749, Korea
[1]Department of Food and Nutrition, Dongeui University, Busan 614-714, Korea

Abstract

The objective of this study was to investigate the effects of iron supplementation and nutrition education on the iron status and anemia of middle school girls in Ulsan city in Korea. The subjects were already diagnosed as having anemia (hemoglobin < 12 g/dL) or iron deficiency (ferritin < 12 ng/mL and/or transferrin sataturation < 14%). Over a period of three months, one iron tablet (80 mg Fe as ferrous sulfate/day) was administered to the iron deficient subjects and two tablets (160 mg Fe as ferrous sulfate/day) were administered to the anemia subjects. Total calorie intake of subjects was 82.1% of RDA. The iron intake of subjects was 91.3% of RDA and the Ca intake was 78.8% of RDA. The basal hemoglobin concentration of subjects averaged 12.8 ± 1.2 g/dL, and this increased significantly ($p < 0.001$) to 13.2 ± 0.9 g/dL after iron supplementation. The basal ferritin concentrations were 14.9 ± 14.2 ng/mL and these significantly increased to 26.6 ± 19.8 ng/mL ($p < 0.001$). The level of total iron binding protein (TIBC) significantly decreased from the initial 523.1 ± 108.7 μg/dL to 462.2 ± 90.2 μg/dL ($p < 0.001$) after iron supplementation. Anemia symptoms such as 'Being bruised easily', 'Inflamed inner mouth', and 'Pale face' improved significantly after iron supplementation in the subjects. There was a negative correlation between their class & year ranking and serum iron level, transferrin saturation after nutritional education and iron supplementation. It was shown, therefore, that the higher the improvement of their anemia level after iron supplementation, the higher their academic performance. It was shown that there was some improvement of their dietary attitudes after nutritional education, and that their serum level related to anemia symptoms and iron nutrition was improved after iron supplementation.

Key words: anemia, iron deficiency, nutritional education, iron supplementation

INTRODUCTION

Well-balanced nutrient intake is essential to healthy development and growth during adolescence when physical growth and emotional development are very active. Research shows, moreover, that health in adolescence may have an effect on the prevention of some adult disease, as well as on mental and emotional stabilization of adolescents (1).

While iron deficiency has been called the most prevalent nutritional problem worldwide, it may occur across all ages and living standards (2), especially, for females due to menstruation. A study carried out with Korea's females shows that iron nutrition is poor (3,4). In particular, research on the iron nutrition of middle school girl students shows that when girl students with transferrin saturation values less than 16% are considered to have anemia, 34% of all the students have anemia from iron deficiency, which means have poor iron nutrition (5). It has been reported that although there has been some improvement in middle school students' body size and quality of dietary life, their iron nutrition is insufficient. It also has been reported that the lower the living standard and the taller the height in middle school students and the more the nutrient intake and the heavier the weight in middle school girls, the higher the risk of their poor iron nutrition.

According to the National Health and Nutrition Survey (6) conducted in 1998, daily iron intake of women between 13 and 19 years of age was 10.8 mg which is just 67.2% of the Recommended Dietary Allowance (RDA) for Koreans, and 69.7% of women in that age group took less than 75% of the RDA. Therefore, it may be pointed out as a nutritional problem in the period of adolescence having high iron demand.

A study conducted by Park et al. (7) with middle school students shows that boys and girls have 86% and 80% of the recommended iron intake, respectively, and that,

†Corresponding author. E-mail: smhong@mail.ulsan.ac.kr
Phone: +82-52-259-2374, Fax: +82-52-259-1699

particularly, the rural girl students have only 77% of the recommended intake of iron. Both of the boys and girls have an insufficient dietary intake of iron which is caused by their low calorie diet, which is less than the recommended level. Also, the frequency of anemia is higher in rural girl students than in urban girl students because they have a poor intake of iron and low calorie diet. It seems, therefore, that nutritional education for youths should be provided effectively and continuously.

Although great emphasis has been put on iron nutrition, particularly, of middle school girls who are more susceptible to iron deficiency, it is necessary to carried out further studies on their iron supplementation, the relation between iron and diet and the effect of iron supplementation. Iron nutrition is very important to middle school girls as iron is required to supplement their blood loss during their monthly period. Though the recognition of the importance of iron nutrition has risen, studies on dosage and supplementation of iron nutrients for middle school girls is hard to find.

Accordingly, this study aims to improve iron nutrition for girls showing malnutrition of iron, and to suggest proposals to prevent anemia, as well as to stress the importance of iron nutrients and diet, by investigating how nutritional education and iron supplementation improves iron nutrition.

MATERIALS AND METHODS

Subjects

This study was carried out with 123 subjects with iron deficiency and anemia of 354 girls who were in the second grade of the girl's middle school in Ulsan Metropolitan city. The standard value defined as anemia in this study was less than a level of 12 g/dL of hemoglobin, for 13 to 15-year girl students, in accordance with NHANES (Nation Heath and Nutrition Examination Survey Ⅲ), while iron deficiency was either less than 12 ng/mL of serum ferritin or less than 14% of transferrin saturation (8).

Anthropometric characteristics

The height and weight were measured with automatic instruments (Fanocs model: Fa-95) and body mass index (BMI) was calculated weight (kg) / height $(m)^2$ (BMI, kg/m^2). PIBW (percent ideal body weight) was percentage of ideal body weight which was measured using the Broca method [{Height (cm) − 100} × 0.9]

Nutritional education and iron supplementation

Nutritional education was provided for the middle school girls with iron deficiency and anemia. The contents of the nutritional education were guidelines of anemia and iron deficiency, understanding for hemoglobin, hematocrit, transferrin saturation, serum iron, and importance of dietary intake for improving of anemia, iron sufficient food, diet therapy in increasing for iron absorption. It was conducted twice, and education targeting their parents was also provided. During the 3 month period of iron supplementation, we made 2~3 phone calls to give nutritional consultation.

In addition to nutrition education, iron supplementation was provided for subjects. It was recommended for the girls with anemia to take 2 tablets (160 mg Fe^{++}), and for the girls with only iron deficiency to take 1 tablet (80 mg Fe^{++}) each day for three months.

Measurement of iron status parameter

Hemoglobin, serum iron, total iron binding capacity (TIBC) and serum ferritin were measured. The hemoglobin, red blood cell hematocrit and RDW (red cell distribution width) were measured with Automatic Blood Cell Counter (Sysmex NE 8000, Toa Medical Electronics Co., Japan). Serum iron and TIBC were measured with Automatic Chemistry Analyzer (Hitachi 747, Hitachi Co., Japan). Serum ferritin concentration were measured with a Chemiluminescence Immunoassay (CLIA) Analyzer (ACS 180, Bayer Diagnostics Co., USA). Transferrin saturation {TS (%)} was calculated by dividing the concentration of serum iron by TIBC.

Survey of nutrient intake, dietary attitude and clinical symptoms of the subjects

Nutrient intakes were measured with a convenient method which was developed by Moon et al. (9). Calculated nutrients were compared with Recommended Dietary Allowance (2000, Korean nutrition society, 7th ed.).

Sixteen items complemented on the basis of clinical symptoms investigated from the previous study were used (10). And improvement of dietary attitude after nutrition education and iron supplementation were investigated. Each item had four scales; 'not improved', 'improved a little', 'improved somewhat', and 'improved a lot' These variables were measured by 1-, 2-, 3-, and 4-point Likert type scales.

Statistical analysis

All data collected were statistically analyzed, using a SPSS PC^+ package. For each variable, the values of average and standard deviation were measured. The hematological indices and clinical symptoms of the subjects were compared by the t-test between before and after nutritional education and iron supplementation. The correlation between hematological indices and class/glade ranking was identified for significance by measuring the Pearson's correlation coefficient.

RESULTS AND DISCUSSION

Anthropometric characteristics of subjects

Table 1 shows the anthropometric characteristics of the subjects. The height and weight were 157.6±5.5 cm, 51.6±10.2 kg respectively. BMI (kg/m^2) was 20.7±3.6 and PIBW (percent ideal body weight) was 99.7±16.9%. The study of Choi et al. (5) of middle school girls reported that the average height was 156.8 cm which is similar to that measured from this study, but their average weight was 49.6 kg which is slightly lower than that measured in this study.

Daily nutrient intakes of subjects

Table 2 shows nutrient intakes of the subjects. This study showed that their total caloric intake was 1724.9 kcal which accounted for only 82.1% of RDA. According to the report of Meada et al. (11), it was shown that when research was done with Japanese middle and high school students after 1966, the students with normal hemoglobin levels accounted for 90% before 1981, and for 98% of boy students and 95% of girl students in 1990. It was insisted, however, that there was a decrease in the number of students with a normal level of hemoglobin after 1991, which was caused by their poor iron intake through low caloric diets for weight reduction.

The average protein intake was 67.4 g which account for RDA. Iron intake was 14.6±4.6 mg (91.3% of RDA) and calcium intake was 630.1±193.1 mg(78.8% of RDA) A study (12) carried out with middle school girls in Seoul showed that their caloric intake accounted for 69.5% of RDA, and that the carbohydrate : protein : fat ratio was 69 : 14 : 17 which was a little bit high in dependance on carbohydrate. Moon et al. (13) reported that both the boy and girl students took less calories and vitamins than their recommended amount, and that their intake of vitamin B_1 was more than its recommended amount. In addition, research on the nutritional intake of high school girl students showed that their intake of calcium accounted for 63.5%~74.3% of its recommended amount (14).

The intake of heme and nonheme iron was 6.1±2.3 mg and 8.5±2.9 mg, respectively, and the rate of heme and nonheme iron to the total iron intake was 41% and 58%, respectively. A study carried out by Hong et al. (15) with high school girls showed that the rate of heme and nonheme iron was 29.6% and 70.4%. Then, it was shown that the heme iron intake of middle school students was more than that of high school girls.

Table 1. Anthropometric characteristics of subjects

	Mean±SD	Range
Age (years)	13.3±0.5	12~14
Height (cm)	157.6±5.5	140~175
Weight (kg)	51.6±10.2	35.0~95.0
BMI (kg/m^2)[1)]	20.7±3.6	15.4~34.4
PIBW[2)]	99.7±16.9	71.8~166.7

[1)]BMI: Body mass index.
[2)]PIBW: Percent ideal body weight, ideal body weight = {height (cm) - 100} ×0.9.

Table 2. Daily nutrient intake and % RDA of subjects

Nutrient	RDA[1)]	Mean±SD	%RDA
Protein (g)	70	67.4±17.6	96.2
Animal protein (g)		36.5±12.9	
Plant protein (g)		30.3±7.6	
Fat (g)		40.3±9.9	
Carbohydrate (g)		273.7±52.3	
Fe (mg)	16	14.6±4.6	91.3
Heme Fe (mg)		6.1±2.3	
Nonheme Fe (mg)		8.5±2.9	
P (mg)	800	990.6±260.7	123.8
Ca (mg)	800	630.1±193.1	78.8
Vitamin A (R.E.)	700	1038.0±432.6	148.3
Vitamin B_1 (mg)	1.1	0.95±0.27	86.4
Vitamin B_2 (mg)	1.3	1.43±0.41	110.0
Niacin (mg)	14	15.6±04.4	111.1
Vitamin C (mg)	70	119.6±52.4	171.1
Total calorie (kcal)	2100	1724.9±337.7	82.1

[1)]RDA: Recommended Dietary Allowance (2000).

Improvement of dietary attitudes after nutritional education

In Table 3, 1 point was given to 'Not improved', 2 points to 'Improved a little', 3 points to 'Improved somewhat', and 4 points to 'Improved a lot' when surveying the improvement of dietary attitudes of subjects after nutritional education and iron supplementation. 'Restricted coffee or tea right after meal (2.70±1.25)' was highest, followed by 'Increased consumption of vitamin C-rich food (2.34±1.02)', 'Tried to maintain optimum body weight (2.20±0.97)', 'Had more balanced-diet (2.19±0.92)', 'Improved regularity of meal time (2.15±0.98)', 'Increased protein-rich food consumption (2.13±0.82)', 'Increased iron-rich food consumption (1.99±0.90)', 'Had

Table 3. Improvement of dietary attitudes of subjects after nutritional education

Dietary attitude	Mean±SD[1)]
Restricted coffee or tea right after meal	2.70±1.25
Increased consumption of vitamin C-rich food	2.34±1.02
Tried to maintain optimum body weight	2.20±0.97
Had more balanced-diet	2.19±0.92
Improved regularity of meal time	2.15±0.98
Increased protein-rich food consumption	2.13±0.82
Increased iron-rich food consumption	1.99±0.90
Had more food to increase iron absorption	1.97±0.83
Iron supplement	1.92±1.03

[1)]Score = Not improved: 1, Improved a little: 2, Improved somewhat: 3, Improved a lot: 4.

more food to increase iron absorption (1.97±0.83)', 'Iron supplement (1.92±1.03)'.

Changes of iron status parameters after nutritional education and iron supplementation

Table 4 shows iron status parameters before and after iron supplementation. Hemoglobin was used as an index to determine if there is anemia with iron deficiency because it decreased in the last process of iron deficiency.

The basal hemoglobin concentration of anemia subjects averaged 12.8±1.22 g/dL, and this increased significantly ($p<0.001$) to 13.2±0.9 g/dL after iron supplementation. The basal ferritin subjects were 14.9±14.2 ng/mL and these significantly increased to 26.6±19.8 ng/mL ($p<0.001$).

In general, hemoglobin and hematocrit levels change in the last process of iron deficiency. When iron deficiency is not serious, therefore, their level frequently appears to be within the normal range (16). The level of serum ferritin is often used as an index which shows the level of iron stored within the body. Serum ferritin concentration is an index that reflects well the amount of iron storage *in vivo*. It is known that a serum ferritin concentration of less than 20 ng/mL is considered to indicate iron deficiency (17).

TIBC is measured by the amount of iron to be bonded to transferrin and it increases quickly when iron is deficient (16). The level of TIBC significantly decreased from the initial 523.1±108.7 μg/dL to 462.2±90.2 μg/dL ($p<0.001$) after iron supplementation. TS (%) is calculated by dividing the concentration of serum iron by TIBC. It has been presented as a more reliable criterion for iron deficiency anemia since the value of serum iron decreases but TIBC increases when there is an iron deficiency. TS (%) were 11.7±5.8% at baseline, and increased to 21.7±11.7% ($p<0.001$) and serum iron were increased 60.2±28.7 μg/dL to 96.2±45.7 μg/dL ($p<0.001$).

Improvement of anemia symptoms after nutritional education and iron supplementation

Table 5 shows Improvement of anemia symptoms after nutritional education and iron supplementation by 4 point scales: 1 point to 'Not improved', 2 points to 'Improved a little', 3 points to 'Improved somewhat', and 4 points to 'Improved a lot'.

The symptoms of 'Being bruised easily (2.63±4.40)' was highest, followed by 'Inflamed inner mouth (2.39±1.41)', 'Pale face (2.28±1.24)', 'Decreasing ability to concentrate (2.26±1.06)', 'Poor memory (2.22±1.07)', 'Get a cold easily (2.22±1.00)', 'Cold hand and feet (2.15±1.17)', 'Difficult digestion (2.15±1.02)', 'Suffering from constipation (2.15±1.24)', 'Feeling dizzy when standing up (2.13±0.87)', 'Tiring out easily (2.09±1.01)', 'Being dizzy usually (2.09±0.96)', 'Shortening of breath when going upstairs (2.07±0.92)', 'No appetite (2.05±0.99)', 'Having headache (2.04±1.00)', 'Feeling blue (2.00±1.13)'. When the clinical symptom of anemia were examined after nutritional interview in the previous study (18), it was reported that there was a significant decrease in the two symptoms of 'Cold hand & feet' and 'Tired out easily'.

Table 6 shows the changes of iron deficiency rates after nutritional education and iron supplementation. The prevalence of anemia(hemoglobin <12 g/dL) were 15.4% before iron supplementation, and its prevalence was significantly decreased to 7.3% ($p<0.05$). The number of

Table 4. Changes of hematological indices after nutritional education and iron supplementation

Hematological indices	Before	After	Significance
	Mean±SD		
Hb (g/dL)[1]	12.8±1.2	13.2±0.9	***
Hct (%)[2]	36.7±3.1	42.1±29.7	*
Ferritin (ng/mL)	14.9±14.2	26.6±19.8	***
Iron (μg/dL)	60.2±28.7	96.2±45.7	***
TIBC (μg/dL)[3]	523.1±108.7	462.2±90.2	***
TS (%)[4]	11.7±5.8	21.7±11.7	***
RBC[5]	4.5±0.3	4.6±0.3	NS[6]

[1]Hb: Hemoglobin.
[2]Hct: Hematocrit.
[3]TIBC: Total iron binding capacity.
[4]TS: Transferrin saturationl.
[5]RBC: Red blood cell.
[6]NS: Not significant.
*$p<0.05$, ***$p<0.001$.

Table 5. Changes of clinical symptoms after nutritional education and iron supplementation

Clinical symptoms	Mean±SD[1]
Being bruised easily	2.63±4.40
Inflamed inner mouth	2.39±1.41
Pale face	2.28±1.24
Decreasing ability to concentrate	2.26±1.06
Poor memory	2.22±1.07
Get a cold easily	2.22±1.00
Cold hand & feet	2.15±1.17
Difficult digestion	2.15±1.02
Suffering from constipation	2.15±1.24
Feeling dizzy when standing up	2.13±0.87
Tiring out easily	2.09±1.01
Being Dizzy usually	2.09±0.96
Shortening of breath when going upstairs	2.07±0.92
No appetite	2.05±0.99
Having headache	2.04±1.00
Feeling blue	2.00±1.13

[1]Score = Not improved: 1, Improved a little: 2, Improved somewhat: 3, Improved a lot: 4.

Table 6. Changes of iron deficiency rates after nutritional education and iron supplementation

Hematological indices	Deficiency	Before	After	Significance
		N (%)		
Hb (g/dL)[1]	<12	19 (15.4)	9 (7.3)	**
Hct (%)[2]	<36	43 (35.0)	7 (5.7)	*
Ferritin (ng/mL)	<12	76 (61.8)	22 (17.9)	***
Iron (μg/dL)	<60	66 (53.7)	24 (19.5)	***
TIBC (μg/dL)[3]	>400	116 (94.3)	94 (76.4)	***
TS (%)[4]	<14	101 (82.1)	35 (28.5)	***
Ferritin<12 ng/mL and/or TS%<14%		122 (99.2)	42 (34.1)	***

[1]Hb: Hemoglobin.
[2]Hct: Hematocrit.
[3]TIBC: Total iron binding capacity.
[4]TS: Transferrin saturation.
*p<0.05, **p<0.01, ***p<0.001.

subjects that hematocrit was below 36% was decreased from the baseline 35.0% to 5.7% ($p<0.001$). And the number of subjects with ferritin <12 ng/mL was decreased from 61.8% to 17.9% ($p<0.001$), and the number of subjects with serum iron <60 μg/dL was decreased from 53.7% to 19.5% ($p<0.001$). The number of subjects with TS (%) <14% subjects was decreased from 82.1% to 28.5% ($p<0.001$), and the number of subjects with ferritin <12 ng/mL and/or TS (%) <14% subjects was decreased from 99.2% to 34.1% after nutritional education and iron supplementation.

School grade changes after nutritional education and iron supplementation

The subjects did not show any significant change in their class & grade ranking between before and after nutritional education and iron supplementation (Table 7). Before the nutritional education and iron supplementation, no significant interrelation was shown between the class & grade ranking and iron status parameters. But, there was a negative correlation between their class & grade ranking, serum iron level and TS (%) after nutritional education and iron supplementation (Table 8). It was shown, therefore, that the higher the improvement of their iron status after nutritional education and iron supplementation, the higher their academic performance. Studies on the effect of iron supplementation showed that when iron was provided for adolescents every week for 3 months, there was a significant increase in their serum ferritin (19), and that when iron was given to high school girls with iron deficiency, there was a remarkable increase in their memory and linguistic ability (20). When this study was carried out with middle school girl students who had either anemia or iron deficiency, it was shown that there was some improvement of their dietary attitudes after nutritional education, and that their serum level related to anemia symptoms and iron nutrition was improved after 3 months of supplementation. It is required, therefore, to continuously plan and provide nutritional education designed for young people help them develop proper habits of eating habits and lifestyle, and to take active measures, such as the supplementation of nutrition and iron, if their iron nutrition is poor.

Table 7. Changes of school grades after nutritional education and iron supplementation

	Before	After	Significance
Class ranking[1]	20.03±11.37	20.01±11.32	NS[3]
Grade ranking[2]	175.9±102.2	176.6±101.7	NS

[1]Student No. of one class: 37~38.
[2]Student No. of grade: 354.
[3]NS: Not significant.

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Table 8. Correlation between class & grade ranking and hematological indices before and after iron supplementation (n=123)

Valuables		Hb[1]	Hct[2]	Ferritin	Iron	TIBC[3]	TS[4]
Before	Class ranking	0.116	0.127	0.065	-0.079	0.079	-0.103
	Grade ranking	0.091	0.094	0.083	-0.113	0.010	-0.107
After	Class ranking	-0.060	-0.164	-0.171	-0.180*	0.063	-0.181*
	Grade ranking	-0.046	-0.161	-0.151	-0.213*	0.116	-0.226*

[1]Hb: Hemoglobin. [2]Hct: Hematocrit. [3]TIBC: Total iron binding capacity. [4]TS: Transferrin saturation.
*p<0.05.

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