

Iron Status of Female Athletes Involved in Aerobic Sports

Hye Young P. Kim¹, Young Ai Jang³ and Pil Young Lee²

¹Department of Food and Nutrition and ²Community Sports and Leisure Studies, Yongin University, Kyunggi Do 449-714, Korea

³Department of Korea Institute of Food Hygiene, Seoul 156-050, Korea

ABSTRACT

The present study was designed to compare the nutrient intake and iron status of athletic female students majoring in aerobics (n=18) to those of age-matched (20–22 yr) sedentary controls (n=19). The athletic students were exercising regularly for 9.1 ± 1.4 hrs/wk and the mean training period of aerobics was 2.9 ± 0.2 years. Means of height, weight, and body mass index calculated as the Quetlet index were similar between athletic and sedentary students. However, mean body fat % of the athletic students ($22.3 \pm 1.0\%$) was significantly lower than that of the sedentary controls ($25.8 \pm 0.6\%$), indicating the effects of routine exercise. Mean daily iron intake was not significantly different between groups (9.9 ± 0.7 mg vs. 10.9 ± 0.8 mg), but much lower than the Korean RDA (18 mg/d) in both groups. Dietary calcium intake of the athletic students was significantly lower than that of the sedentary controls. Hematocrit (Hct) and hemoglobin (Hb) values were significantly lower in the athletic students than in the sedentary students (Hct : $40.0 \pm 0.7\%$ vs. $43.8 \pm 0.5\%$; Hb : 12.6 ± 0.3 g/dl vs. 14.8 ± 0.3 g/dl). However, other iron status values such as serum iron, TIBC, and transferrin saturation were not significantly different between groups. Therefore, the low hemoglobin levels in the athletic group are probably due to plasma dilution in endurance-trained individuals. Serum ferritin level was a little lower in the athletic group, but no significant difference between groups was found. Serum triglyceride concentration in the athletic students was significantly lower than that in the control students. In conclusion, the findings suggest that regular training of female athletes majoring in aerobics is associated with an increased risk of pseudoanemia due to plasma volume expansion and a decreased risk of coronary heart disease by decreasing body fat and blood lipid level.

KEY WORDS : iron status · female athletes · sports anemia · exercise · aerobics.

INTRODUCTION

Iron deficiency is one of the most common nutritional problems in women. Iron is an integral component in hemoglobin, myoglobin, cytochromes, and many enzymes involved in oxygen utilization.¹⁾ It is known that physical training and inadequate nutrition affect iron status.^{2,3)} Subclinical iron deficiency especially seems to be an important problem in elite athletes.⁴⁾

Anemia can impair exercise performance because reduced hemoglobin concentration is associated with reduced blood oxygen content.^{5,7)} As hemoglobin concentration decreases, a linear reduction in maximum oxygen consumption and exercise capacity ensues. Iron status seems to be related to the intensity and type of exercise. Endurance athletes seem to be more prone to iron storage reduction than athletes involved in anaerobic sports.⁸⁻¹⁰⁾ Iron deficiency, even without anemia, may reduce mitochondrial iron-dependent enzymes, causing a decrease in the aerobic capacity.¹¹⁻¹³⁾

The type of anemia in sportsmen has been frequently called as sports anemia or athlete's anemia in order to emphasize its character.¹⁴⁻¹⁶⁾ Among many possible causes that

may bring about the development of sports anemia, the most commonly recognized causes are plasma expansion due to training, iron deficiency, and loss of erythrocytes by way of bleeding into digestive and urinary systems.³⁾

Aerobics is a popular body training exercise in Korea. Athletes majoring in aerobics are often educated to restrict their diet for a thinner body shape and to undergo strenuous training for aerobic competitions. These processes may lead these athletes to subclinical iron deficiency. However, little is reported about iron status of these athletes in Korea. Therefore, the purpose of this study is to examine the nutrient intake and iron status of female athletes majoring in aerobics.

SUBJECTS AND METHODS

This study was conducted on eighteen female university students majoring in aerobics. The students were exercising regularly for 9.1 ± 1.4 hrs/wk. The mean training period of aerobics was 2.9 ± 0.2 years. Nineteen female students who had not participated regularly in any form of exercise for the past 3 years were recruited to form a sedentary control group.

Each subject was requested to complete 3-day dietary

records that were averaged to obtain estimates of daily nutritional intake. Dietary records were analyzed for nutrient content using the computer aided nutritional analysis (CAN) program (Korean Nutrition Society, Korea).¹⁷ The nutrient values of the diets were compared with the Korean Recommended Dietary Allowances.¹⁸

Body mass index (BMI) was calculated as the Quetlet index (weight(kg)/height(m²)). Percent body fat was determined by bioelectric impedance method (Gil Woo Co., Korea).

Blood samples were taken from an antecubital vein following a 12-hr overnight fast. Whole blood was immediately analyzed for hematocrit and hemoglobin contents. Hematocrit value was measured by a microhematocrit technique and hemoglobin content was analyzed by using cyanmethemoglobin method (Young Dong Co., Korea). The remaining whole blood was then centrifuged at 2,000 rpm for 30 minutes. Serum was divided into aliquots and stored frozen at -32°C until further analysis. Serum iron level and total iron binding capacity (TIBC) were measured utilizing a ferrozine colorimetric method (Sigma diagnostics, No 565, USA). Percent transferrin saturation was determined by computing the ratio of serum iron to the TIBC. Serum ferritin level was measured by using a ¹²⁵I-radioimmunoassay kit (Amersham International, UK). Total cholesterol and triglyceride concentrations were analyzed by test kits (Young Dong Co., Korea).

Comparison between the athletic group and the sedentary control group was performed by an unpaired Student t-test.¹⁹ A probability value of $p < 0.05$ was chosen as the level of statistical significance. Pearson's correlation coefficients were calculated between hematologic and dietary variables.

RESULTS AND DISCUSSION

1. Physical characteristics of the subjects

Physical characteristics of the subjects are presented in Table 1. No significant difference was found for age, height, weight, or body mass index between the athletic and the control group. The mean height of the total sub-

Table 1. Physical characteristics of subjects.

Variables	Aerobics (n=18)	Controls (n=19)
Age (year)	21.2 ± 0.5	22.0 ± 0.5
Height (cm)	160.4 ± 0.7	160.7 ± 0.9
Weight (kg)	50.5 ± 1.0	49.6 ± 1.3
BMI (kg/m ²)	19.7 ± 0.3	19.2 ± 0.5
Body fat (%)	22.3 ± 1.0	25.8 ± 0.6*

Data is mean ± standard error of mean (SEM).

BMI : body mass index (kg/m²). * $p < 0.05$

jects was 160.6cm, mean weight was 50.0kg, and mean body mass index was 19.4. However, mean percent body fat of the athletic group (22.3±1.0%) was significantly lower than that of the control group (25.7±0.6%), indicating the effects of routine exercise in lowering body fat.

2. Daily intake of nutrients

Daily nutrient intake and comparison with the Korean RDA are shown in Table 2. Mean energy and protein intake of the subjects was not significantly different between the athletic and the control groups. Mean daily energy intake of the total subjects was 1633.0 kcal (81.7% of the Korean RDA). Mean protein intake of the subjects was 63.3 g, which was within the RDA of 60 g/d. Similar results in energy and protein intake were found in other studies with non-athletic Korean female students.²⁰⁻²³

Mean daily iron intake was similar between athletic and control students, but slightly lower than that reported by others.²⁰⁻²³ Both groups had very low daily iron intake averaging only 54.8-60.8% of Korean RDA. Therefore, increasing the iron intake of these students up to the RDA levels is recommended. Mean vitamin C consumption in this study was over the RDA in both groups (166.2–234.4% of RDA), which might had been helpful in increasing the absorption of dietary non-heme iron.

Mean calcium intake of all subjects was 434.6 mg/d, only 62.1% of the Korean RDA (700 mg). In addition, mean calcium intake of the athletic group (356.4 mg) was significantly less than that of the control group (512.8 mg). Therefore, it is recommended to increase daily Ca intake to prevent Ca-deficiency symptoms, especially in the athletic group. The mean daily cholesterol intake of both groups was within the recommended value (<300 mg).

Table 2. Daily intake of nutrients (% RDA)

Variables	Aerobics		Controls	
	mean intake	%RDA	mean intake	%RDA
Energy (kcal)	1564.0±68.6	78.2	1701.4±101.2	85.1
Protein (g)	59.6± 4.3	99.3	67.0± 4.8	111.7
Animal protein (g)	30.5± 3.7		36.5± 3.1	
Plant protein	29.1± 1.5		30.5± 2.2	
Fat (g)	41.2± 2.6		46.1± 2.9	
Carbohydrate (g)	240.6±11.3		251.5± 15.3	
Crude fiber (g)	4.4± 0.4		5.3± 0.4	
Vitamin C (mg)	91.4±11.3	166.2	128.9± 21.8	234.4
Iron (mg)	9.9± 0.7	54.8	10.9± 0.8	60.8
Animal source (mg)	2.7± 0.3		3.0± 0.3	
Plant source (mg)	7.2± 0.5		8.0± 0.7	
Ca (mg)	356.4±28.4	50.9	512.8± 50.1*	73.3
Cholesterol (mg)	199.9±36.8		278.4± 29.2	

Data is mean ± SEM. * $p < 0.05$

3. Blood iron status of the subjects

The blood iron status values of the subjects are presented in Table 3. Mean values for all blood parameters were within the normal range in both groups.^{24,42,43} Hematocrit (Hct) and hemoglobin(Hb) values were significantly lower in the athletic group than in the control group, as previously reported by several investigators.²⁵⁻²⁷ The percent of MCHC followed the Hb level and was significantly lower in the athletic group. Serum iron, TIBC, and transferrin saturation were not different between two groups. Weight *et al.*^{28,29} attributed reduction in hemoglobin levels with normal serum iron to plasma volume expansion. Therefore, the subnormal Hb and Hct levels in the athletic group of this study might be due to plasma expansion resulting from training rather than to real anemia of the students. Serum ferritin, which have been recognized as a good index of storage iron, was not significantly different between two groups, though the value in the athletic group was slightly lower than the value in the control group. Serum ferritin has been more frequently found to be marginal in female athletes than in controls.³⁰⁻³³ Karamizrak *et al.*¹⁰ reported that ferritin stores of athletes were about 30% less than normal as shown in this study. Magnusson *et al.*³⁴ have suggested that there may be a shift in iron storage from reticuloendothelial cells to hepatocytes in athletes, rather than a diminished body iron supply.

Blood hemoglobin and serum ferritin concentrations are two of the most widely used chemical indicators of iron status. In a study with 1,743 Finnish men,³⁵ the duration and frequency of physical activity were associated inversely with serum ferritin and blood hemoglobin. Because there was an association between high serum ferritin and an excess risk of acute myocardial infarction in their subjects, they suggested a reduction in stored iron levels as a mechanism by which leisure time physical activity decreases the risk of coronary heart disease. In addition, Edgerton *et al.*³⁶ reported that a low serum ferritin value was not associated

Table 3. Blood iron status of subjects.

Variables	Aerobics	Controls	Criteria for deficiency
Hct (%)	40.0 ± 0.7	43.8 ± 0.5***	<36 ⁴²⁾
Hb (g/dl)	12.6 ± 0.3	14.8 ± 0.3***	<12 ⁴²⁾
MCHC (%)	32.4 ± 0.9	33.9 ± 0.4*	<30 ⁴²⁾
serum iron (µg/dl)	108.8 ± 9.5	107.7 ± 8.6	<60 ⁴³⁾
TIBC (µg/dl)	387.1 ± 17.6	381.8 ± 13.7	>390 ⁴³⁾
TS (%)	29.2 ± 3.3	29.3 ± 2.8	<15 ⁴³⁾
serum ferritin (µg/l)	18.1 ± 3.0	23.6 ± 5.2	<10 ⁴³⁾

Hct : Hematocrit Hb : Hemoglobin
MCHC : mean corpuscular hemoglobin concentration
TIBC : total iron binding capacity TS : transferrin saturation
*p<0.05, ***p<0.001

with impairment in exercise performance or work capacity in the adult. Therefore, the decrease in serum ferritin found in the athletes may be a sign for coronary heart disease prevention in the other sense.

4. Blood lipid status of the subjects

Blood lipid status of the subjects is shown in Table 4. Mean values for serum triglyceride and cholesterol contents were within the normal ranges for both groups. Triglyceride concentration of the athletic group was significantly lower than that of the control group. The average cholesterol concentration in the athletic students was also slightly lower than that of the control students, but no significant difference was found. Because no differences in daily energy, fat, carbohydrate, and cholesterol intake were found between two groups, the difference in serum triglyceride is probably due to the effects of exercise.¹⁾

5. Correlation coefficients among biochemical indices

Correlation coefficients among hematological indices are presented in Table 5. Significant positive correlations were found between Hb and both Hct and MCHC ($\gamma=0.68$ and 0.74 , respectively, $p<0.001$). Serum iron had a significant positive correlation with transferrin saturation ($\gamma=0.92$, $p<0.001$), while TIBC had a negative correlation with TS ($\gamma=-0.62$, $P<0.001$). Ferritin had weak positive correlations with serum iron and transferrin saturation ($\gamma=0.32$ and 0.34 , respectively, $p<0.1$).

Significant positive correlations were found between serum triglyceride and blood iron indices, such as hematocrit, hemoglobin, and TIBC (Table 6). Meanwhile, serum cholesterol did not show strong correlations with hematology

Table 4. Serum lipid status of subjects.

Variables	Aerobics	Controls
Triglyceride (mg/dl)	59.2 ± 4.6	99.0 ± 11.2**
Cholesterol (mg/dl)	165.7 ± 5.8	174.7 ± 7.0

Data is mean ± SEM. **p<0.01

Table 5. Correlation coefficients among hematological indices.

Variables	Hb	MCHC	sFe	TIBC	TS	ferritin
Hct	0.68***	0.01	0.32	-0.06	0.28	-0.16
Hb		0.74***	0.06	0.13	-0.01	-0.19
MCHC			-0.20	0.24	-0.26	-0.08
sFe				-0.30	0.92***	0.32
TIBC					-0.62***	-0.17
TS						0.34

Hct : Hematocrit Hb : Hemoglobin
MCHC : mean corpuscular hemoglobin concentration
sFe : serum iron TIBC : total iron binding capacity
TS : transferrin saturation
***p<0.001

Table 6. Correlation coefficients between serum lipid levels and blood iron indices.

serum lipid	Mean ± SD	Hct	Hb	MCHC	sFe	TIBC	TS	ferritin
TG (mg)	79.1 ± 41.2	0.44**	0.55***	0.33	0.05	0.36*	-0.09	0.31
cholesterol (mg)	170.2 ± 27.3	0.21	-0.01	-0.22	-0.34	0.08	-0.29	-0.27

Hct : Hematocrit Hb : Hemoglobin MCHC : mean corpuscular hemoglobin concentration
 sFe : serum iron TIBC : total iron binding capacity TS : transferrin saturation TG : triglyceride
 * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7. Correlation coefficients between nutrient intake levels and blood iron indices.

Nutrients	Mean ± SD	Hct	Hb	MCHC	sFe	TIBC	TS	ferritin
Calorie (kcal)	1633 ± 357.8	-0.02	0.26	0.38*	-0.24	0.00	-0.19	-0.29
Fat (g)	43.6 ± 11.4	-0.08	0.35*	0.53**	-0.28	0.10	-0.25	-0.23
Carbohydrate (g)	246.1 ± 55.0	-0.01	0.22	0.32	-0.28	-0.05	-0.20	-0.27
Protein (g)	63.3 ± 18.8	0.00	0.11	0.14	-0.20	-0.04	-0.13	-0.15
Iron (mg)	10.4 ± 3.0	-0.08	0.15	0.26	-0.32	-0.06	-0.24	-0.11
animal iron (mg)	2.9 ± 1.2	-0.06	0.07	0.14	-0.07	0.04	-0.04	-0.14
plant iron (mg)	7.6 ± 2.6	-0.05	0.14	0.23	-0.31	-0.09	-0.24	0.30
Vitamin C (mg)	110.1 ± 73.1	0.18	0.27	0.20	-0.02	-0.35	0.12	0.07
Cholesterol (mg)	239.1 ± 140.6	0.01	0.12	0.14	0.03	-0.11	0.06	-0.26

Hct : Hematocrit Hb : Hemoglobin MCHC : mean corpuscular hemoglobin concentration
 sFe : serum iron TIBC : total iron binding capacity TS : transferrin saturation
 * $p < 0.05$, ** $p < 0.01$

gical indices. The strong positive correlations between serum triglyceride and blood iron status are probably related to low serum triglyceride and blood iron status in the athletic group.

When correlations among nutrient intake levels and blood iron indices were compared, daily fat intake had positive correlations with hemoglobin and MCHC (Table 7). MCHC was also positively correlated with energy and carbohydrate intake. Therefore, it is suggested that blood iron status is also affected by energy-yielding nutrients, when daily iron intake is low. Lamanca and Haymes¹¹ reported that total iron intake had strong positive correlations with ferritin. However, in our study, no significant correlations were found between total iron intake and blood indices. It may be due to similar iron intake levels among subjects. Meanwhile, daily intake of plant iron, which occupies 73% of daily iron, had weak positive correlations with serum ferritin ($\gamma = 0.30$, $p < 0.1$).

CONCLUSION

The present study was performed to evaluate the iron status of athletic students majoring in aerobics. The results obtained in this study showed that daily intake of iron was very low in both the athletic and the control students. Because adequate nutrition is a protective factor for subclinical iron deficiency, it is advisable for all students to pay attention to dietary iron intake qualitatively and quantitatively.

In this study, Hb and Hct values in female athletes

were lower than those in control subjects. Several other investigators attributed the reduction in Hb values, at least in endurance sports, to plasma volume expansion resulting from training, rather than to a real decrease in the total body content of hemoglobin. Because other indices in iron status such as serum iron and transferrin saturation were not different between the two groups, the female athletes in this study were probably showing this plasma volume expansion effects.

Even though no significant difference was found between groups, serum ferritin levels were slightly lower in the athletic group. There are reports that iron supplementation to athletes can increase serum ferritin level and improve fitness.^{37,41} Therefore, more studies are necessary to evaluate the effect of iron supplementation on athletes.

Finally, the female athletes were similar to age-matched control students in body mass index and energy intake. However, their percent body fat and serum triglyceride levels were significantly lower than those in the controls. Therefore, it is suggested that regular aerobic training at a certain level in these subjects is beneficial in preventing the occurrence of chronic degenerative diseases. In conclusion, the findings suggest that regular training of female athletes majoring in aerobics is associated with an increased risk of pseudoanemia due to plasma volume expansion and a decreased risk of coronary heart disease.

Literature cited

- 1) Shils ME, Olson JA, Shike M. Modern nutrition in health and disease.

- 8th ed., Lean and Febiger, 1994
- 2) Weaver CM, Rajaram S. exercise and iron status. *J Nutr* 122 : 782-787, 1992
 - 3) Szygula Z., Erythrocytic system under the influence of physical exercise and training. *Sports Medicine* 10(3) : 181-197, 1990
 - 4) Rowland TW. Iron deficiency in the young athlete. *Pediatric Clin North Am* 37(5) : 1153-1163, 1990
 - 5) Balaban EP. Sports anemia. *Clin Sports Med* 11(2) : 313-325, 1992
 - 6) Clement DB, Sawchuk LL. Iron status and sports performance, *Sports Med*, 1 : 65-74, 1984.
 - 7) Woodson RD. Hemoglobin concentration and exercise capacity. *Am Rev Respir Dis* 129 : s72-s75
 - 8) Newhouse I, Clement D. Iron status in athletes : An update. *Sports Medicine* 5 : 337-352, 1988
 - 9) Schena F, Pattini A, Mantovanelli S. Iron status in athletes involved in endurance and in prevalently anaerobic sports. In : Kies CV, Driskell JA. Sports Nutrition. CRC Press Inc., 1995
 - 10) Karamizrak, SO, Islegen C. Varol SR, Taskiran Y, Yaman C, Mutaf I, Akgun N. Evaluation of iron metabolism indices and their relation with physical work capacity in athletes. *Br J Sports Med* 30 : 15-19, 1996
 - 11) Lamanca JJ, Haymes EM. Effects of low ferritin concentration on endurance performance, *Int J Sport Nutr* 2 : 376-385, 1992
 - 12) Schoene RB, Escourrou P, Robertson HT, Nilson KL, Parsons JR, and Smith NJ. Iron repletion decreases maximal exercise lactate concentration in female athletes with minimal iron-deficiency anemia. *J Lab Clin Med* 102(2) : 306-312, 1983
 - 13) Diehl DM, Lohman TG, Smith SC, Kertzner RJ. The effects of physical training in iron status of female field hockey players. *Int J Sports Med* 7 : 264-270, 1986
 - 14) Hallberg L, Magnusson B. The etiology of Sports Anemia. *Acta Med Scandi* 216 : 145-148, 1984
 - 15) Selby GB, Eichner ER. Endurance swimming, intravascular hemolysis, anemia, and iron depletion : new perspective on athlete's anemia. *Am J Med* 81 : 791-794, 1986
 - 16) Pate R. Sports anemia : A review of the current research literature. *Physician Sports Med* 1 : 115-126, 1983
 - 17) Korean Nutrition Society. Computer aided nutritional analysis program. 1997
 - 18) Korean Nutrition Society. Recommended Dietary Allowances for Koreans. 6th ed., 1995
 - 19) SAS Institute Inc. SAS User's Guide : Statistics. 5th ed., SAS Institute.
 - 20) Nam HS, Ly SY. A survey on iron intake and nutritional status of female college students of Chungnam national university. *Korean J Nutr* 25(5) : 404-412, 1992
 - 21) Sung CJ. A study on the dietary fiber intake and iron metabolism in Korean female college students. *Korean J Nutr* 30(2) : 147-154, 1997
 - 22) Kwak CS, Kim JS, Choi HM. Effects of dietary animal protein and plant protein on iron bioavailability in young Korean women. *Korean J Nutr* 27(5) : 451-459, 1994
 - 23) Kim SM, Kim JR. A study on the nutritional iron status of adults in Taegu city. *J Korean Soc Food Sci Nutr* 27(1) : 191-199, 1998
 - 24) Gibson RS. Principles of nutritional assessment. Oxford University Press. New York. 1990
 - 25) Frederickson LA, Puhl JL, Runyon WS. Effect of training on indices of iron status of young female cross-country runners. *Med Sci Sports Exercise* 15 : 271-276, 1983
 - 26) Convertino VA, Keil LC, Greenleaf JE. Plasma volume, renin and vasopressin responses to graded exercise after training. *J Appl Physiol : Respi Environ Exercise Physiol* 54 : 508-514, 1983
 - 27) Rajaram S, Weaver CM, Lyle RM, Sedlock DA, Martin B, Templin TJ, Beard JL, Percival SS. Effects of long-term moderate exercise on iron status in young women. *Med Sci Sports Exerc* 27(8) : 1105-1110, 1995
 - 28) Weight LM, Klein M, Noakes TD, Jacobs P. Sports anemia-A real or apparent phenomenon in endurance trained athletes? *Int J Sports Med* 13 : 344-347, 1992
 - 29) Weight LM, Darge BL, Jacobs P. Athletes' pseudoanemia. *Eur J Appl Physiol*. 62 : 358-362, 1991
 - 30) Fogelholm M. Inadequate iron status in athletes : an exaggerated problem? In : Kies CV, Driskell JA. Sports Nutrition. CRC Press Inc., 1995
 - 31) Powell PD, Tucker A. Iron supplementation and running performance in female cross-country runners. *Int J Sports Med* 12 : 462-467, 1991
 - 32) Williford HN, Olson MS, Keith RE, Barksdale JM, Blessing DL, Wang NZ, Preston P. Iron status in women aerobic dance instructors. *Int J Sport Nutr* 3(4) : 387-397, 1993
 - 33) Pate RR, Miller BJ, Davis JM, Slentz CA, Klingshirn LA. Iron status of female runners. *Int J Sport Nutr* 3(2) : 222-231, 1993
 - 34) Magnusson B, Hallberg L, Rossander L, Swolin B. Iron metabolism and "sports anemia". II. A hematological comparison of elite runners and control subjects. *Acta Med Scand* 216 : 149-164, 1984
 - 35) Lakka TA, Nyyssonen K, Salonen JT. Higher levels of conditioning leisure time physical activity are associated with reduced levels of stored iron in Finnish men. *Am J Epidemiol* 140 : 148-160, 1994
 - 36) Edgerton VR, Ohira Y, Hediarchchi J, Senewiratne B, Gardner GW, Barnard RJ. Elevation of hemoglobin and work tolerance in iron-deficient subjects. *J Nutr Sci Vitaminol* 27 : 77-86, 1981
 - 37) Rowland TW, Deisroth MB, Green GM, Kelleher JF. The effect of iron therapy on the exercise capacity of nonanemic iron-deficient adolescent runners. *Am J Dis Child* 142 : 165-169, 1988.
 - 38) Jensen CA, Weaver CM, Sedlock DA. Iron supplementation and iron status in exercising young women. *J Nutr Biochem* 2 : 368-373, 1991
 - 39) Lyle RM, Weaver CM, Sedlock DA, Rajaram S, Martin B, Melby CL. Iron status in exercising women : the effect of oral iron therapy vs increased consumption of muscle foods. *Am J Clin Nutr* 56(6) : 1049-1055, 1992
 - 40) Lamanca JJ, Haymes EM. Effects of iron repletion on VO₂ max, endurance, and blood lactate in women. *Med Sci Sports Exerc* 25(12) : 1386-1392, 1993
 - 41) Fogelholm M, Jaakkola L, Lampisjarvi T. Effects of iron supplementation in female athletes with low serum ferritin concentration. *Int J Sports Med* 13(2) : 158-162, 1992
 - 42) WHO(World Health Organization) Nutritional Anemia. WHO Technical Report Series No. 3. World Health Organization, Geneva, 1972
 - 43) Herbert V. Recommended dietary intakes of iron in humans. *Am J Clin Nutr* 45 : 679-686, 1987