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Assessment of Nutritional Status by Estimation of Nutrients and Food Intakes of the Lead Workers in Republic of Korea*

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ABSTRACT

The purpose of this study was to assess the nutritional status of Korean workers with occupational exposure to lead by estimating nutrients and food intakes so that we can eventually establish the dietary guidelines to be recommended for the lead workers. Food consumption survey was conducted by a 24-hr recall method with 135 lead workers and 50 non-exposed controls. Food intake data were converted into nutrients intake using computer aided nutritional analysis program. Mean daily energy intake and percentage of recommended daily allowance (RDA) of male lead workers were 2138 kcal and 87% of RDA while those of control were estimated as 2234 kcal and 91% of RDA. Mean daily intakes of nutrients of male lead workers were 78 g (111% RDA) for protein, 502 mg (71% RDA) for calcium, 11.7 mg (97% RDA) for iron, 665 μgR.E (95% RDA) for vitamin A, 1.39 mg (108% RDA) for thiamin, 1.14 mg (77% RDA) for riboflavin, 15 mgN.E (92% RDA) for niacin and 66 mg (94% RDA) for vitamin C. On average, male lead workers showed significantly lower protein, calcium, iron, sodium, potassium, niacin and vitamin C intakes than control group while cholesterol intake of the male lead workers was significantly higher than that of control group. Intakes of calcium of male lead workers were less than 75% RDA meaning that nutritional intake of calcium of male lead workers was insufficient and could possibly result in nutritional deficient. Some food groups such as milk, meat and fish must be strongly suggested to improve nutritional status of lead workers. Continuing nutrition monitoring and appropriate nutrition intervention for lead workers must be conducted further.

KEY WORDS: dietary intake, nutritional status, Korean lead workers.

INTRODUCTION

According to the regular medical surveillance of lead workers in Korea, mainly by annual health examinations and biological monitoring, it has been reported that the number of lead poisoning cases during the past two decades has decreased.[1)2)] However the incidences of major chronic diseases such as heart disease, stroke, hypertension, diabetes and some forms of cancer that are the leading causes of adult death have been increased among lead workers.[3)] Since many nutritional factors contribute to risk for chronic diseases, recent changes in diet and life style have been repeatedly suggested to be the important causes for increase of the major chronic diseases among Koreans.[4)] These diseases are often preventable. An understanding of nutrition and the role it plays in short-term and long-term health can significantly minimize risk for chronic diseases. This means that regular nutrition monitoring and intervention for lead workers are important to keep their health.

Despite the changes in diet patterns of Koreans, malnutrition of some nutrients including iron (Fe), calcium (Ca) vitamin A and riboflavin is still prevalent in Korea.[4)5)] Not only malnutrition could impact on the performance,[6)7)] but also malnutrition of Fe or Ca could be more susceptible to lead poisoning.[8)9)] There is a substantial body of evidence suggesting that lead absorbed reacts with a few nutrients such as Ca, Fe, fat, phosphate and some vitamins in vivo.[10 13)]

In order to decrease the adverse health effects caused by lead exposure it is important to maintain adequate nutritional status. There are, however, no previous reports concerning the nutritional status of Korean lead workers. The objectives of the present study were to assess the nutritional status of Korean lead workers using 24-hr recall method so that we can eventually establish not only the dietary guideline of nutrients intakes relative to health promotion and disease prevention for Korean lead workers but also information on imbalances among food

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groups and excessive intake of food components deleterious to health.

MATERIALS AND METHODS

1. Study population

Participation in the study was voluntary and all participants provided written, informed consent. One hundred thirty five lead workers who have received mandatory special health examination by Institute of Industrial Medicine at Soonchunhyang University were recruited and participated in two site-visit examinations at two different lead-using facilities. Fifty control subjects without occupational lead exposure were recruited from among those visited Soonchunhyang University Hospital at Chonan for a mandatory annual medical examination for non-lead using industry workers.

2. Assessment of body fat contents

All participants' height and weight were measured. Body mass index, a traditional anthropometric parameter of body composition,[14] was calculated by dividing the weight in kilogram by the square of height in meters.

Bioelectrical impedance was measured with the subject standing upright on a four platform-type terminal impedance plethysmograph (Model TBF-501, Tanita, Japan) according to the manufacturer's instructions.

3. Nutrient intake assessment

Food consumption survey was conducted using one-day 24-hr recall by one to one interview with trained interviewers. Detailed descriptions of all foods and beverages consumed and estimated food portion sizes were recorded by interviewers with the use of food models, standard household measures and natural-sized colored photographs as memory aids.

Food records were converted to nutrient intake by using the computerized nutrient analysis program (CAN-pro, Korean Society of Nutrition, 1998, Seoul, Korea). For mixed dishes participants were asked of all ingredients if possible. For those instances in which recipes for mixed dishes were not available, recipes were identified from commonly available cookbooks[15][16] and used as the standard for the remainder of the study. Nutrient intakes from nutritional supplements were not considered because brand labels, doses, and durations of intake were not recorded with sufficient accuracy. Nutrient intakes were calculated as percent of recommended daily allowance (RDA) according to RDA values of each sex and age according to Korean RDA.[17]

4. Statistical analysis

All statistical analyses were conducted using SPSS statistical software (Version 10.0). Students' t-test was used to compare values between groups.

RESULTS

General characteristics of subjects were shown in Table 1. The subjects were aged from 20 to 79 years old (n = 185). Age range of lead workers was from 20 to 66 while that of control group was from 24 to 79. Mean ages of control and lead workers were 40.8 and 38.9, respectively. Compared to control group, lead workers had a significantly higher proportion of male subjects (87.4% vs. 68.0%, $p < 0.01$). There were no significant differences between two groups in height, weight and body mass index (BMI). Control group showed significantly higher percent body fat (25.7%) than lead workers (22.7%)($p < 0.05$).

Table 2 showed the average daily nutrients intakes of the subjects. Due to the different proportion of either the male or the female subjects between control and lead worker group, we analyzed nutrient intake values of male and female subjects separately. Energy intakes of control group were higher than those of lead workers for both male and female subjects although the difference was significant only for the females. Control group showed more than 75% of RDA in all nutrients analyzed in the study for both male and female subjects. Male lead workers, however, did not show sufficient intake of Ca (less than 75% of RDA). Intakes of protein, Ca, Fe, sodium (Na), potassium (K), niacin and vitamin C of male lead workers were significantly lower than those of control group. Cholesterol intake was significantly higher in male lead workers ($p < 0.001$) while fat intake of male subjects did not show any significant difference between two groups. The female lead workers showed very poor nu-

Table 1. General characteristics of the control and lead workers

Category	Control (n = 50)	Lead workers (n = 135)
Sex M (%)	34 (68.0)	118 (87.4)
F (%)	16 (32.0)	17 (12.6)
Age (yrs)	40.84 ± 11.56[1)]	38.92 ± 10.71
Height (cm)	165.71 ± 6.97	167.83 ± 7.54
Weight (kg)	63.55 ± 10.73	64.87 ± 9.78
Body mass index (BMI)	23.08 ± 3.23	23.06 ± 3.39
Body fat (%)	25.74 ± 6.53	22.67 ± 6.08*

1) Values are mean ± S.D.
*: $p<0.05$

Table 2. Mean daily intakes of energy and nutrients of control and lead workers

	Male (n = 152)		Female (n = 33)	
	Control (n = 34)	Lead workers (n = 118)	Control (n = 16)	Lead workers (n = 17)
Energy (kcal)	2234.08 ± 705.11[1)] (91.0)[2)]	2138.18 ± 626.93 (86.6)	2012.71 ± 633.06 (101.53)	1612.72 ± 541.11* (82.51)
Protein (g)	89.26 ± 35.83 (128.0)	78.00 ± 27.78* (111.5)	74.34 ± 31.20 (134.63)	60.16 ± 20.52 (109.38)
Fat (g)	57.21 ± 41.18	51.29 ± 23.77	47.23 ± 25.40	34.67 ± 16.39
Carbohydrate (g)	322.95 ± 76.02	315.80 ± 86.41	317.96 ± 92.04	252.10 ± 81.74*
Ca (mg)	600.75 ± 221.58 (85.8)	502.16 ± 202.80** (71.7)	529.24 ± 210.63 (75.61)	326.43 ± 95.95*** (46.63)
P (mg)	1286.80 ± 377.82 (183.3)	1172.32 ± 383.26 (167.1)	1120.39 ± 397.06 (160.06)	874.28 ± 231.82* (124.90)
Fe (mg)	15.77 ± 4.79 (131.4)	11.70 ± 6.20** (97.5)	11.89 ± 4.11 (79.79)	9.04 ± 4.20* (64.38)
Na (mg)	6582.39 ± 2463.22	4366.89 ± 1554.30***	4956.01 ± 1707.84	3612.66 ± 1161.13**
K (mg)	3283.98 ± 912.85	2482.77 ± 684.69***	2874.42 ± 1220.70	1847.10 ± 570.86**
Vit. A (μgR.E.)	824.39 ± 398.06 (117.8)	665.25 ± 738.34 (95.0)	613.07 ± 351.00 (87.58)	426.01 ± 267.54 (60.86)
Vit. B_1(mg)	1.43 ± 1.05 (111.7)	1.39 ± 0.56 (108.7)	1.21 ± 0.58 (120.69)	0.99 ± 0.38 (98.51)
Vit. B_2(mg)	1.23 ± 0.57 (83.6)	1.14 ± 0.55 (76.9)	1.03 ± 0.49 (85.17)	0.69 ± 0.22* (57.80)
Niacin (mgN.E.)	19.55 ± 8.33 (118.2)	15.30 ± 6.22*** (91.8)	15.98 ± 7.10 (122.29)	13.17 ± 6.22 (101.31)
Vit. C(mg)	132.66 ± 60.0 (189.5)	65.90 ± 34.43*** (94.14)	126.67 ± 92.47 (180.96)	52.02 ± 22.49** (74.31)
Cholesterol (mg)	243.43 ± 155.01***	353.78 ± 201.49	257.10 ± 166.62	201.47 ± 137.33

1) Values are mean ± S.D.
2) Values in parentheses are % of RDA
Means with asterisks are significantly (*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$) different between control and lead workers

Table 3. Percent of carbohydrate, protein and fat contribution to energy intake

Nutrients	Control	Lead workers	Total
Carbohydrate	59.85 ± 12.30[1)]	60.63 ± 9.76	60.42 ± 10.47
Protein	15.68 ± 3.02	14.55 ± 2.39*	14.86 ± 2.62
Fat	22.23 ± 8.37	20.82 ± 6.09	21.20 ± 6.79

1) Values are mean ± S.D. *: $p < 0.05$

Table 4. Contribution of foods for cholesterol intakes

Foods	Control (mg)	Lead workers (mg)
Egg	96.96	160.22
Anchovy	36.85	52.32
Pork	32.41	20.98
Squid	20.78	46.90
Beef	11.55	14.02
Yellow croaker	10.94	2.45
Crab	9.76	1.58
Mackerel	7.22	1.05
Donuts	3.52	-
Milk	2.40	3.04
Oyster	2.01	-
Ice cream	0.62	1.44
Soft cake	-	7.81
Loach	-	3.95

Table 5. Distribution of nutrients intakes of the participants according to their intake levels

Nutrient	RDA < 75%		75% < RDA < 100%		RDA > 100%	
	Control	Lead workers	Control	Lead workers	Control	Lead workers
Energy	26	35	32	42	42	23
Protein	12	17	18	34	70	49
Vit A	26	53	22	24	52	23
Vit C	2	23	8	20	90	57
Vit B_1	20	21	34	31	46	48
Vit B_2	60	55	12	29	28	16
Niacin	12	36	34	30	54	34
Ca	48	66	34	18	18	16
P	2	4	4	5	94	91
Fe	28	35	28	35	44	30

trients intake levels compared to the female control group as well as male lead workers. Intakes of Ca, Fe, vitamin A, vitamin B_2 and vitamin C of female lead workers were less than 75% of RDA.

Among three energy nutrients, proportion of energy from carbohydrate, protein and fat were 60%, 15% and 21%, respectively (Table 3). As expected, carbohydrate

Table 6. Contributions of each food group to nutrients intakes in the subjects of control and lead worker

	Energy (kcal)		Protein (g)		Fat (g)		Calcium (mg)		Iron (mg)	
	Control	Lead workers	Control	Lead workers	Control	Lead workers	Control	Lead workers	Control	Lead workers
Plant foods										
Cereals	221.20 ± 179.90[1]*	265.48 ± 154.67	4.48 ± 4.35*	5.16 ± 2.97	1.64 ± 3.63	1.74 ± 3.02	6.94 ± 15.34	7.17 ± 10.41	0.53 ± 1.02	0.53 ± 1.05
Potatoes	27.69 ± 32.71	26.59 ± 34.53	0.85 ± 0.72	0.87 ± 0.62	0.03 ± 0.06	0.05 ± 0.07	3.68 ± 6.41	3.38 ± 7.00	0.30 ± 0.22	0.31 ± 0.20
Sugars	27.67 ± 72.41	16.35 ± 16.64*	0.12 ± 1.08	0.01 ± 0.17	0.42 ± 3.80	0.06 ± 0.64	0.63 ± 3.96	0.16 ± 0.90*	0.03 ± 0.19	0.004 ± 0.04*
Legumes	34.42 ± 23.39	36.60 ± 31.40	3.20 ± 2.32	3.68 ± 3.10	1.61 ± 1.56*	2.31 ± 2.17	32.60 ± 29.64*	43.72 ± 42.22	0.62 ± 0.43	0.63 ± 0.52
Seeds	5.68 ± 10.57	12.15 ± 40.11	0.14 ± 0.14	0.48 ± 1.81	0.38 ± 0.38	0.94 ± 3.42	4.97 ± 2.52	6.85 ± 15.13	0.08 ± 0.11	0.08 ± 0.16
Oils	18.42 ± 19.08	18.87 ± 16.26			2.09 ± 2.16	2.14 ± 1.84				
Vegetables	4.60 ± 6.40	3.59 ± 5.06*	0.38 ± 0.58	0.30 ± 0.45*	6.64 ± 0.14	5.34 ± 0.12*	7.97 ± 13.96	5.89 ± 10.81*	0.16 ± 0.31	0.11 ± 0.22*
Mushrooms	5.34 ± 4.72	8.92 ± 7.86	0.61 ± 0.45	0.65 ± 0.54	0.05 ± 0.07	0.09 ± 0.09	1.19 ± 1.15	0.88 ± 0.80	0.19 ± 0.12	0.12 ± 0.10
Seaweeds	7.20 ± 4.34	6.48 ± 3.73	0.70 ± 0.50	0.63 ± 0.34	0.05 ± 0.07	0.05 ± 0.05	24.11 ± 23.36	23.38 ± 22.43	0.36 + 0.19	0.32 ± 0.18
Fruits	68.41 ± 66.00	85.58 + 80.09	0.53 ± 0.46	0.66 ± 0.78	0.22 ± 0.25*	0.63 ± 0.72	6.92 ± 6.67*	14.94 ± 18.58	0.45 ± 0.51*	0.70 ± 0.99
Spices	5.95 ± 11.74	3.17 ± 5.97*	0.33 ± 0.68	0.21 ± 0.39*	0.21 ± 0.67	0.09 ± 0.31*	2.26 ± 3.49	1.42 ± 2.32*	0.07 ± 0.12	0.05 ± 0.09*
Beverages	56.96 ± 136.63	65.15 ± 149.69	0.25 ± 0.80	0.34 ± 1.11	0.03 ± 0.16	0.03 ± 0.13	4.95 ± 22.95	4.61 ± 11.32	0.16 ± 0.56	0.35 ± 2.94
Subtotal (%)	483.54 ± 567.89 (62)	548.93 ± 546.01 (74)	11.59 ± 12.08 (34)	12.99 ± 12.28 (46)	13.37 ± 12.95 (40)	13.47 ± 12.58 (54)	96.22 ± 129.45 (48)	112.40 ± 141.92 (50)	2.95 ± 3.78 (61)	3.20 ± 6.49 (67)
Animal foods										
Meats	182.43 ± 349.18	54.03 ± 56.57*	13.23 ± 19.81	6.27 ± 9.75*	13.49 ± 28.73	4.34 ± 10.20*	6.38 ± 14.03	2.48 ± 5.92*	1.02 ± 1.32	0.59 ± 1.44*
Milks	46.19 ± 46.23	66.71 ± 131.51	1.28 ± 1.99	1.87 ± 2.53	3.02 ± 2.32	3.44 ± 2.90	42.77 ± 66.43	61.85 ± 83.68	0.04 ± 0.11	0.08 ± 0.20
Eggs	37.59 ± 30.54	41.00 ± 32.10	3.01 ± 2.43	3.22 ± 2.55	2.62 ± 2.13	2.84 ± 2.25	11.06 ± 8.97	11.41 ± 9.11	0.43 ± 0.35	0.47 ± 0.37
Fishes	34.42 ± 45.64	26.75 ± 37.12*	4.93 ± 6.42	4.13 ± 4.89	1.38 ± 2.74	0.87 ± 2.36*	44.38 ± 47.41	36.72 ± 44.79	0.43 ± 0.46	0.41 ± 0.46
Subtotal (%)	300.63 ± 471.59 (38)	188.49 ± 257.3 (26)	22.45 ± 30.65 (66)	15.59 ± 19.72 (54)	20.51 ± 35.92 (60)	11.49 ± 17.71 (46)	104.59 ± 136.84 (52)	112.46 ± 143.50 (50)	1.92 ± 2.24 (39)	1.55 ± 2.47 (33)
Total	784.17 ± 1039.48	737.42 ± 803.31	34.04 ± 42.73	28.58 ± 32.00	33.88 ± 48.87	24.96 ± 30.29	200.81 ± 266.29	224.86 ± 285.42	4.87 ± 6.02	4.75 ± 8.96

1) Values are mean ± S.D.
Means with asterisks are significantly ($p < 0.05$) different between control and lead workers

was the major source of energy and the proportion shown in Table 3 represents the typical pattern of Korean diet. Even if energy from protein was statistically lower in the lead worker group, the amount of protein intake was sufficient in both groups (Table 2).

Cholesterol intake of the male lead workers was significantly higher than that of control group (Table 2). Cholesterol intake in excess of 300 mg/day was taken as a criterion of high intake set by Korean Society of Nutrition.[17] The major food sources of cholesterol were listed in Table 4. Lead workers consume more eggs, anchovies and squids than control group and all of these foods are well-known high cholesterol sources.

Distributions of percent RDA of energy and each nutrient are shown in Table 5. Sixty percent of subjects in control group showed insufficient riboflavin intake. However, the average riboflavin intakes of control group were 1.23 mg/day for the male subjects and 1.03 mg/day for the female subjects (Table 2), and the percent RDA's of control group were 83.6% for the male subjects and 85.2% for the female subjects (Table 2). These values are considered to be adequate according to the guidelines of Korean Society of Nutrition.[17] Discrepancy may come from the wide range of intake values (0.21 - 3.96 mg/day) of control group. Intake of Ca of subjects in control group also showed similar tendency. Even if the average intake value of Ca fell in the range of normal intake (600.75 mg/day, 85.8.1% RDA for the male subjects and 529.24 mg/day, 75.6% RDA for the female subjects), 48% of subjects in control group showed insufficient intake (less than 75% of RDA) of Ca. The range of Ca intake of control group was 113.6 - 1358.6 mg/day. More than 50% of lead workers showed less than 75% of RDA of vitamin A, riboflavin and Ca intakes. As mentioned earlier, the reason why 53% of lead workers showed insufficient intake of vitamin A (less than 75% RDA) could be the wide range of vitamin A intake of lead workers (92.7 - 7340.4 μgRE/day).

Table 6 showed the type of food groups as sources of daily energy, protein, fat, Ca and Fe intakes. Since there are many food groups, only selected are listed according to the amount taken by subjects. According to Table 6, Korean lead workers got more energy, fat and Fe mainly from plant foods than from animal foods while contributions of plant food and animal food to daily protein and Ca intakes were similar. Control group, however, showed different tendency in food selections. More protein, fat and calcium were from animal foods than from plant foods although energy and Fe were mostly from plant foods as in the lead worker group.

DISCUSSIONS

A variety of objective methods are used to assess nutritional status including nutritional biochemistries, anthropometric measures, bioelectrical impedance, total body potassium, total body nitrogen, total body electrical conductivity and food or nutrient intakes.[18] However, measurement of nutritional biochemistries, total body potassium, nitrogen, or electrical conductivity requires expensive equipments not generally available.[19] In contrast, measurement of nutrient intake is important in evaluating dietary patterns, nutrition education and intervention programs aimed at improving the dietary intake of population.[20] Therefore, we selected relatively simple methods including bioelectrical impedance and body mass index in addition to food or nutrient intake recording method.

Results of BMI for both control and lead worker groups were not significantly different. Percent body fat measured by bioelectrical impedance was significantly higher in control group compared to lead workers. The subjects in control group were mostly industrial manufacturing workers of electrical or electronic merchandises with relatively low physical activities while lead workers were engaged to highly active physical activities. Since intakes of fat from two groups were not significantly different as well as intake of energy, the significant differences of percent body fat of two groups could be explained by the differences of physical activities. Even if there are more female subjects in control group (32.0%) than in lead worker group (12.6%), gender effect was not significant (data not shown) and the lower body fat of lead workers could be due to the higher physical activities. Lead workers need to consume sufficient food to fulfill the high energy-expenditure. However, no differences for male subjects and even less energy intakes for the female subjects were observed between two groups implicating that energy intakes of lead workers may not be sufficient to fulfill their high energy-expenditure. Lead workers need to be informed to intake more energy. The protein intakes of male lead workers were significantly lower than that of control group although both groups showed more than 100% RDA of protein.

The average Ca intakes of both male and female lead workers were inadequate (less than 75% RDA). Typical Korean diets do not usually include dairy food and consequently many Korean adults have trouble digesting milk or milk products. It is an important issue to introduce dairy products to daily diet in Korea. Especially for lead workers, it is important to keep an adequate Ca status since the absorption of lead from the gastrointestinal tract and the toxicity of the absorbed metal are much influenced by the nutritional status of the individual.[21] As milk is a very good source of both Ca and riboflavin, strong strategy is needed to introduce dairy products to diets of lead workers. Milk has been traditionally promoted as a dietary supplement that has protective effects against lead poisoning. It was common practice, and still is in many circles, for lead-exposed workers to add extra milk to their daily diet.[22] However, since effects of dietary components including Ca, P, Fe, vitamin D, fat and lactose on lead absorption and excretion are evident,[23][24] when viewed individually it is not clear whether the net effect of a number of dietary components in milk will be beneficial or otherwise. Lactose will increase lead absorption[25] and fat increased lead deposition in several tissues[22] whilst other, like calcium, lower absorption.[26] Some components may raise or lower the toxic effects following absorption and finally there are some which increase and some which will cause a diminution in the excretion of absorbed lead. The net effect might either be enhancement or diminution in lead absorption with milk depending on the nutritional status of each specific subject.[27][28] Dietary components, however, would affect lead absorption only when a route of lead exposure was through gastrointestinal tract. Therefore, controversial effects of milk may be preventive if oral contamination of lead can be avoided. Milk consumption will be greatly beneficial due to its wide variety of nutritious components[29] even with some deleterious effects. Additional milk intake as a protection against lead poisoning could be advised with adequate industrial hygiene practices in the work environment.

The Korean Nutrition Society suggests Korean to keep daily cholesterol intake level lower than 300 mg.[17] The high cholesterol intake (353 mg/day) of the male lead workers while fat intake of the male lead workers did not show any significant differences with that of control group, meant there are some serious problems in selection of food groups among lead workers. As shown in Table 4, eggs, anchovies, squids and pork were the major cholesterol sources for lead workers. Although these foods are generally considered to be a good protein sources, due to high cholesterol contents, proper nutrition education might be needed to select better animal protein sources with low cholesterol such as lean meats, skim milk and poultry with white meats, etc. These findings, however, should be evaluated with cautions. In data collecting process, participants in control group visited university hospital for the study. This could be interpreted that most participants had meal of their own selection on the study day, which resulted in the variety of foods with great diversity in control group. On the other hand, lead workers were mostly participated in the meal plan provided by the company. On the study day, they were at work and visited by the investigators so that most of lead workers had 1 or 2 same meals either for lunch or dinner. Menus of these meals on study day could falsely result in high cholesterol intake of lead workers. Despite of all, considering the fact that usual Korean diet does not contain much cholesterol compared to western diets, nutrition education is strongly recommended for lead workers in their selection of foods in the diets.

According to Table 6, Koreans mainly depended on plant foods including cereal as a major energy source (62% and 74% of energy intake for control and lead workers, respectively). Control group took relatively high energy from meats compare to lead workers, which possibly represented the recently changed dietary pattern in Korea. Meats were the major protein source for both control and lead worker group whereas control groups received significantly higher amount of protein from meats than lead workers. Protein sources for lead workers were evenly distributed between plant and animal foods. These results implicate the quality of protein sources for lead workers was not as good as that of control group while the quantity may be sufficient. As long as the protein source is concerned, proper quality is more important than proper quantity. Therefore, protein from animal sources must be emphasized for lead workers.

Food sources for Ca and Fe were similar in both control and lead worker groups. Contributions of plant and animal foods were very similar for Ca while more iron came from plant foods than from animal foods in both control and lead worker groups. Considering quality of mineral nutrients, more calcium and iron should come from animal sources. The control group took 39.5% and lead workers took 32.6% of iron from animal sources, of which meats were the major sources for both groups. However, iron intake from meats for lead workers was significantly lower than that of control. Even if mean iron intake level was assessed as adequate, intakes of foods considered as good iron sources which are often called MFP (meat, fish, poultry) were insufficient for lead workers. Therefore, the biochemical iron status could be low for lead workers and more detailed investigation should be conducted. Adequate iron status is especially important for lead workers since susceptibility for lead toxicity and work performance could be affected.

The prevalence of serious nutritional and food intake problems of Korean lead workers found in the present study includes the inadequacy of Ca and Fe intakes, the poor food sources of Ca and Fe and over-consumption of cholesterol. It is especially important to select appropriate food sources for Ca and Fe mineral nutrients since they are not readily absorbed from poor food source such as plant foods. The overall dietary intakes of Korean lead workers were mostly from food groups including cereals, legumes, vegetables, seaweeds and spices. These results well reflect the typical Korean dietary patterns since the general Korean diet include large proportion of plant foods and spices. In contrast, high cholesterol intake among the male lead workers might result from inappropriate food selection. Therefore, nutritional guidelines for Korean lead workers to suggest to intake larger portions of dairy foods, meat and fish should be cautiously emphasized.

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