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Dietary Intake and Major Dietary Sources of Vitamin B_6 in Korean Young Women*

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ABSTRACT

The dietary vitamin B_6 intake of 218 Korean young women (aged 20 – 26y), who had no health problems, and their sources were estimated using a modified Korean vitamin B_6 database. The average daily vitamin B_6 intake was 0.987 mg for the subjects. About 87.2% of the subjects consumed less than the Korean Recommended Dietary Allowance (RDA) of vitamin B_6. The average ratio of vitamin B_6 intake to daily protein intake was 0.014 mg/g protein, and approximately 91% of subjects consumed < 0.02 mg/g protein. Vitamin B_6 intake was significantly ($p < .01 - p < .001$) positively correlated to the intakes of all other nutrients. Between animal and vegetable protein, animal protein had a stronger positive correlation with vitamin B_6 intake. Foods from animal and plant sources provided 32% and 68%, respectively, of the total vitamin B_6. Major dietary sources of vitamin B_6 in Korean young women were pork, rice, garlic, onion, potatoes, and banana. As for major dietary sources of vitamin B_6, the top 10 foods provided nearly 64% of total vitamin B_6, and dietary contributors of vitamin B_6 for Koreans are less varied than those for Americans.

KEY WORDS: vitamin B_6 intake, food sources, nutrient intake.

INTRODUCTION

Over the past 50 years, research has suggested that vitamin B_6 is an essential nutrient that is involved in human biological systems. Vitamin B_6 is involved in gluconeogenesis, niacin formation, lipid metabolism, nervous system, nucleic acids, immune system and hormone modulation.[1] Vitamin B_6 metabolism and requirements may be altered in several diseases and pathological conditions, including cardiovascular heart disease, diabetes, alcoholism and asthma.[2] The Korean Nutrition Society started to present the Korean Recommended Dietary Allowance (RDA) for vitamin B_6 in 1995 and renewed it in 2000. Since there is little data on vitamin B_6 status for Koreans, the Korean RDA had to be established on the basis of Western data, which is based on Western dietary habits and intake. However, Korean dietary habits and intake are different from those in the West since nutrient requirements are affected by physio-cultural factors including race. Because vitamin B_6 is frequently identified as a nutrient with a high prevalence of inadequate intakes even in the Western countries[3-8] and the intake of animal food is sufficient in these Western countries and the major food sources of vitamin B_6 are animal food and the bioavailability of vitamin B_6 from animal food is higher than that from plant food, there might be a potential for inadequate dietary vitamin B_6 in Korea.

Thus, the purpose of this study was to estimate the dietary vitamin B_6 intake and its food sources in Korean young women by using a modified Korean vitamin B_6 database.[8].

SUBJECTS AND METHODS

1. Subjects

Two hundred eighteen young women aged 20 to 26 with no health problems participated in this study. Characteristics of the subjects are given in Table 1. Subjects for the study were college students who took a nutrition class. All subjects were taught and tested on exact food portion sizes.

2. Dietary intake and anthropometric data

Three days (2 days during the week and 1 day on the weekend) recall method was used to record the usual dietary intake of subjects. Food portion sizes were estimated by using standard household measures and published average portion sizes.[10] Recorded food intakes were converted into vitamin B_6 and nutrient intakes by using a com-

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puterized dietary analysis program.[12] This program database does not include vitamin B_6 information. Therefore, a vitamin B_6 value was assigned to all foods reported by the subjects. The sources used to determine the vitamin B_6 content of foods included the Korean RDA Food values[8] and USDA agriculture handbooks.[13] When information was unavailable for a particular food cod, a value was assigned based on values for similar foods. The foods in the vitamin B_6 database were categorized into those of animal or plant origin and the amount of daily vitamin B_6 provided by these two categories was calculated for each person. The methods used for the determination of quantitative contribution of various foods to daily vitamin B_6 intake of the subjects followed the method of Block. *et al.*[14] The percent contribution of foods in a particular category was determined by dividing the total vitamin B_6 from all servings of foods in a category by the total vitamin B_6 consumed by all individuals in the sample. On the day of collection of dietary data, weights and heights were reported and body mass index (BMI) was calculated from the measurements of body weight and height. Statistical analyses were performed with SAS program.

RESULTS

General characteristics of the subjects are given in Table 1. Table 2 shows the total daily vitamin B_6, mg vitamin B_6 /1000 kcal, mg vitamin B_6/g dietary protein intake, and the percent of Korean RDA of vitamin B_6 for Korean young women. The estimated average daily intake of vitamin B_6 for Korean young women was 0.987 ± 0.39 mg, range was from 0.23 to 2.43 mg/day and was 70.5 ± 27.9% of Korean RDA. The daily vitamin B_6 intake from plant and animal sources for the subjects expressed as a percent of total is also shown in Table 2. Foods from animal and plant sources provided 32.2 ± 12.3% and 67.8 ± 12.4%, respectively, of the total vitamin B_6.

Fig. 1 and 2 show the frequency distribution of vitamin B_6 intakes of percent Korean RDA and relative to daily protein intake. 12.8% of all subjects had intakes ≥ 100% of the RDA for vitamin B_6 (the RDA is 1.4 mg for women aged 20–26 y). Approximately, 18.9% of the subjects had estimated intakes < 50% of the RDA. As for vitamin B_6 to protein ratio, 42.7% of the subjects within 0.01–0.015 mg vitamin B_6/g protein, 35.3% of the subjects within 0.015–0.02, 13.3% of the subjects within less than 0.01, and 8.7% of the subjects within more than 0.02 on the survey day.

There were correlations between vitamin B_6 intake and nutrient intake per day (Table 3). As expected, vitamin B_6 intake had a positive correlation with all other nutrients. Among major nutrients, protein intake and fat intake ($p < 0.001$) had stronger positive correlations with vitamin B_6

Table 1. General characteristics of the subjects (n = 218)

Category	Mean ± S.D.
Age (yrs)	22.1 ± 0.5
Height (cm)	162.6 ± 4.7
Weight (kg)	51.9 ± 5.9
Body mass index (BMI)[1]	19.6 ± 1.9

1: Body mass index (BMI) = Weight (kg) / Height (m)^2

Table 2. Dietary vitamin B_6 intake of the subjects (n = 218)

	Average	Range
Vitamin B_6 per day (mg/d)	0.987 ± 0.390	0.23 – 2.43
Vitamin B_6 per 1000 kcal (mg/1000 kcal)	0.509 ± 0.149	0.150 – 0.987
Vitamin B_6 per g protein (mg/g protein)	0.014 ± 0.004	0.004 – 0.030
Percent of RDA (%)[1]	70.5 ± 27.9	16.4 – 173.6.
Vitamin B_6 form plant foods (%)	67.8 ± 12.4	26.3 – 96.2
Vitamin B_6 form animal foods (%)	32.2 ± 12.3	3.8 – 73.7

1: Recommended Dietary Allowances for Koreans, 7th Revision, 2000

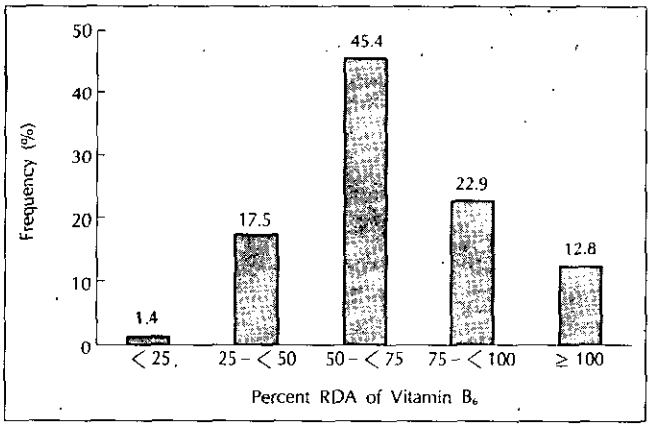

Fig. 1. Frequency distribution of vitamin B_6 intake (% of RDA).

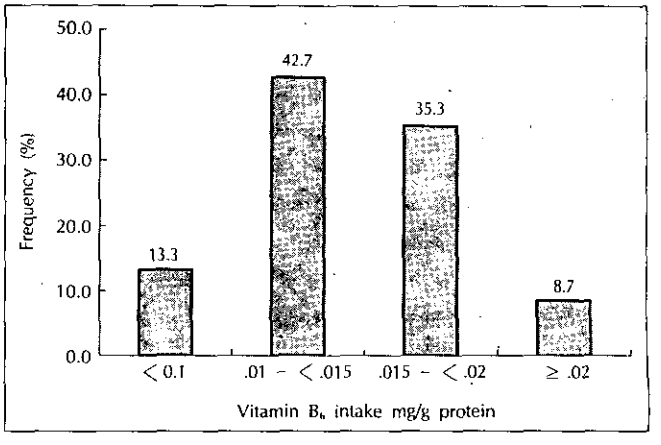

Fig. 2. The frequency distribution of vitamin B_6 intake (mg/g protein).

Table 3. Correlation between vitamin B_6 intake and nutrient intake per day (n=218)

Nutrients	Vitamin B-6 (mg)
Total protein (g)	0.47793***
Animal (g)	0.53252***
Vegetable (g)	0.22581**
Total fat (g)	0.49115***
Animal (g)	0.48239***
Vegetable (g)	0.22724**
Carbohydrate (g)	0.19665**
Ca (mg)	0.40066***
P (mg)	0.65181***
Fe (mg)	0.33086***
Na (mg)	0.38412***
K (mg)	0.68381***
Vitamin A (RE)	0.35112***
Vitamin B_1 (mg)	0.72618***
Vitamin B_2 (mg)	0.52096***
Niacin (mg)	0.26806**
Vitamin C (mg)	0.50368***
Cholesterol (mg)	0.31978***

: significant at $p < 0.01$ *: significant at $p < 0.001$

intake than carbohydrate intake ($p < 0.01$). Also, animal protein and animal fat had stronger positive correlations with vitamin B_6 than vegetable protein and vegetable fat. Among micronutrients, phosphorus, potassium, vitamin B_1, vitamin B_2, and vitamin C had strong positive correlations with vitamin B_6 (correlation coefficient > 0.50).

The 50 major food sources of vitamin B_6 in the diet, providing - 96.4% of the total daily vitamin intake, and the percent of the population consuming the food on the survey day are shown Table 4. Pork, loin, raw was the number one contributor with 12.74% of the daily intake of vitamin B_6. The vitamin B_6 content of rice is 0.11 mg/100 g. However, rice ranked second, contributing 12.7% of the total intake because it was consumed frequently and in quantity. Although garlic is not a good food source of vitamin B_6, with vitamin B_6 content of 0.0096 mg/serving, because of the frequency and amounts usually consumed, it provided 8.82% of the total daily vitamin intake. Onions contributed 6.09% and potatoes in various forms provided 6.38%.

Table 5 lists the 50 foods reported by the subjects with the highest vitamin B_6 content expressed per serving and per 100 g of food. A comparison of Table 3 and 5 reveals that the top 10 foods in the two tables had only 3 foods in common. Four foods, namely rice, garlic, ordinary liquid milk, and chicken's eggs were not present in Table 5. Although carrot juice, sweet potatoes, tomato juice, and liver are good sources of vitamin B_6 per usual serving, the frequency of consumption is low.

DISCUSSION

Estimates of vitamin B_6 intake reported here were compared with estimates from the US population data for young women aged 19 - 34 y.[4] In the NHANES Ⅱ, young white and black women in the age groups 19 - 34 y averaged 1.18 and 1.11 mg/day, respectively, compared with 0.987 mg/day for the women in this study. The vitamin B_6 intake was 70.5% of the Korean RDA in the present. However, the percent of RDA of vitamin B_6 intake for young white and black women was lower (58 and 54% of the RDA). Also, in the NHANES Ⅱ, 89.5% of total white women and 94% of total black women reported vitamin B_6 intakes less than the RDA, compared with 87.2% in this study. Thus, although estimated vitamin B_6 intake per day in this study was lower than the NHANES Ⅱ, the consumption of vitamin B_6 in young women of this study was better than young women of the NHANES Ⅱ in terms of the percent of RDA for vitamin B_6.

The vitamin B_6 requirement is affected by the level of dietary protein intake, with the requirement growing with increasing protein consumption[15-17]. Hence, the adequacy of dietary intakes of the vitamin is frequently evaluated in terms of mg vitamin B_6/g protein consumed.[2] The RDA of Korea and US[8,9] for vitamin B_6 is based on the ratio of 0.02 mg/g dietary protein. In this study, the average ratios of vitamin B_6 intake to daily protein intake were 0.014, which was lower than in the NHANES Ⅱ (0.019 and 0.018 mg/g dietary protein for young white and black women). Also, when the distribution rather than the mean is examined, 91.3% of the subjects in this study consumed < 0.02 mg vitamin B_6/g protein. However, approximately 67% of women in the NHANES Ⅱ consumed < 0.02 mg vitamin B_6/g protein. Biochemical indices of vitamin B_6 nutritional status were not measured both in the NHANES Ⅱ and in this study. Thus, it remains to be established whether vitamin B_6 intakes less than those recommended are incompatible with adequate vitamin B_6 nutritional status.

As expected, there were positive correlations between vitamin B_6 intake and all other nutrient intakes in this study. Between animal and vegetable protein, animal protein had a stronger positive correlation with vitamin B_6 intake. Foods that are good sources of vitamin B_6 are animal foods such as fish, pork, chicken, eggs, and organs of animals.[8] Brown rice, soybeans, and oats are also good so-

Table 4. Major dietary sources of vitamin B_6 for subjects

Rank	Description	Percent of total Vitamin B_6	Cumulative percent of Vitamin B_6	Percent of population
1	Pork, Loin, Raw	12.74	12.74	37.92
2	Rice, Paddy Rice, Well-milled rice, Japonica type	12.70	25.44	87.77
3	Garlic, Bulb	8.82	34.26	87.46
4	Onion, Raw	6.09	40.35	72.02
5	Potatoes, Raw	5.08	45.43	27.68
6	Banana, Raw	4.53	49.96	10.24
7	Chicken's egg, Whole egg, Fresh	3.80	53.76	71.41
8	Cow's milk, Liquid milk, Ordinary liquid milk	3.78	57.54	42.35
9	Corn Flakes	3.23	60.77	5.81
10	Carrot, Raw	3.11	63.87	47.25
11	Tomato, Raw	3.01	66.89	15.44
12	Watermelon	2.77	69.65	13.46
13	Melon, Raw	2.00	71.66	18.04
14	Fast Foods, Chicken Breast, Meat only breaded and fried	1.58	73.23	3.06
15	Chicken, Meat and skin, Raw	1.55	74.78	5.66
16	Sugar, Powdered	1.50	76.28	25.23
17	Lettuce, Improved	1.43	77.71	12.84
18	Beef, Imported Cattle, Rib, Raw, Japanese	1.42	79.12	3.06
19	Fast Foods, Pizza	1.28	80.40	4.43
20	Spinach, Raw	1.07	81.47	10.40
21	Cabbage, Raw	1.03	82.50	27.83
22	Beef, imported Cattle, Flank, Raw	1.02	83.52	5.66
23	Cucumber, Improved	0.93	84.45	40.83
24	Soybean curd, Soybean curd	0.89	85.34	32.87
25	Fast Foods, Potatoes, French-fried	0.87	86.21	6.12
26	Radish root, Korean radish root	0.75	86.96	25.69
27	Tomato, juice	0.70	87.66	2.14
28	Beer	0.63	88.29	2.6
29	Rice, Paddy Rice, Brown rice	0.61	88.90	2.6
30	Ice cream, vanilla	0.60	89.50	14.37
31	Pork, Belly	0.57	90.07	4.74
32	Mackerel, Fresh	0.54	90.61	4.28
33	Pork products, Sausage, Frankfurt	0.44	91.06	14.37
34	Potatoes, Potato Chips	0.43	91.49	2.29
34	Sweet potatoes, Raw	0.43	91.92	2.45
36	Leek	0.36	92.28	9.94
37	So Myon, Dried	0.35	92.62	8.41
37	Strawberry, Raw, Native	0.35	92.97	3.98
39	Carrot, juice, Canned	0.34	93.31	0.76
39	Chinese Cabbage, Korean Cabbage, Raw	0.34	93.65	3.82
41	Hair tail, Fresh	0.33	93.98	2.6
42	Common squid, Fresh	0.31	94.29	10.09
43	Yellow-fin tuna, Fresh	0.30	94.59	0.76
44	Pineapple, Raw	0.28	94.87	2.14
45	Pork, Pork products, Luncheon meat, Canned	0.23	95.11	2.91
45	Orange juice, Raw	0.23	95.34	3.36
47	Fast Foods, Eggs and cheese Sandwich	0.21	95.55	1.53
48	Wheat, Wheat Flour, Medium flour	0.19	95.74	17.74
49	Sweet pepper, Green	0.18	95.91	6.12
50	Buckwheat noodle, Dried	0.16	96.08	0.92
50	Orange, Raw	0.16	96.24	1.68
50	Pork, Pork products, Ham, Canned, Raw	0.16	96.40	1.22

Table 5. *Vitamin B_6 content of foods reported by the subjects*

Rank	Description	Vitamin B_6 mg/serving	Vitamin B_6 mg/100g
1	Yellow-Fin tuna, fresh	0.460	0.92
2	Carrot, Juice, Canned	0.440	0.22
3	Fast Foods, Potatoes, French-fried	0.359	0.26
4	Potatoes, Raw	0.351	0.27
5	Corn Flakes	0.282	0.94
6	Sweet potatoes, Raw	0.270	0.27
7	Tomato, Juice	0.260	0.13
8	Pork, Edible Viscera, Liver, Braised	0.257	0.57
9	Fast Foods, Ham and Cheese Sandwich	0.246	0.14
10	Pork, Loin, Raw	0.228	0.57
11	Blue fin tuna, Fresh	0.220	0.44
12	Pork, Pork products, Ham, Canned, Raw	0.204	0.51
13	Tomato, Raw	0.200	0.08
13	Fast Foods, Chicken, Brest, Meat only, Breaded and fried	0.200	0.35
15	Spaghetti, Dry	0.198	0.11
16	Fast Foods, Potato salad	0.195	0.15
17	Fast Foods, Pizza	0.192	0.12
17	Banana, Raw	0.192	0.32
19	Pepper, Green pepper, Improved	0.189	0.27
20	Rice, Paddy Rice, Brown rice	0.186	0.62
21	Carrot, Raw	0.175	0.25
22	Chestnut, Raw	0.174	0.29
23	Beef, Imported Cattle, Flank, Raw	0.168	0.42
24	Fast Foods, Cheeseburger	0.167	0.09
25	Soybean, Yellow soybean, Dried	0.164	0.82
26	Fast Foods, Eggs and cheese Sandwich	0.158	0.09
27	Beef, Imported Cattle, shank, Braised	0.153	0.34
28	Potatoes, Potato chips	0.150	0.50
29	Spinach, Raw	0.140	0.20
30	Turban shell, Fresh	0.136	0.17
31	Mackerel, Fresh	0.135	0.27
32	Stem of taro, Raw	0.133	0.19
33	Melon, Musk	0.132	0.11
34	Rice, Paddy Rice, Rice flour	0.129	0.43
35	Watermelon	0.125	0.05
36	Hair tail, Fresh	0.120	0.24
36	Beer	0.120	0.06
38	Crab, Blue crab, Fresh	0.119	0.17
39	Eel, Eel, Fresh	0.115	0.23
40	Pork, Rids, Raw	0.114	0.38
41	Celery	0.112	0.16
41	Sweet pepper, Green	0.112	0.16
43	Onion, Raw	0.110	0.22
44	Fast Foods, Hamburger, Regular	0.105	0.07
44	Chinese Cabbage	0.105	0.15
44	Leek	0.105	0.15
47	Corn Bread, Dry mix, Prepared	0.100	0.10
47	Grape juice, Canned or bottled	0.100	0.10
47	Pacific cod, Fresh	0.100	0.20
47	Cow's milk, Liquid milk containing recombined milk, low fat	0.100	0.05

urces of vitamin B_6, but milk products have relatively small amounts of vitamin B_6. Phosphorous, vitamin B_1, and vitamin B_2, which are key contents of meat, fish, and chicken had stronger positive correlations with vitamin B_6 than other micronutrients. Vitamin B_2 and niacin needed for the interconversion of the different forms of vitamin B_6[10] had strong positive correlations with vitamin B_6 intake. If vitamin B_6 intake decreases, vitamin B_2 and niacin intake may be decreased at the same time, and inadequacies of these two B-complex vitamins may affect the metabolism of vitamin B_6.

The adequacy of reported vitamin B_6 intakes for meeting requirements is also influenced by the bioavailability of the vitamin from different food sources. The bioavailability of vitamin B_6 from food varies because the bioavailability of vitamin B_6 is incomplete when it is conjugated with β-glucosides[18] and is adversely affected by (animal) protein,[15][19][20] the bioavailability of vitamin B_6 in alcoholic beverages may be relatively high. However, not all vitamin B_6 in foods are readily bioavailable; plant sources are generally less bioavailable than are animal sources. According to the results presented in Table 2, the young women in this study obtained ~67.8% from plant sources, whereas in the NHANES Ⅱ approximately one-half of the dietary vitamin B_6 was reported to come from animal foods and one-half from plant foods. In comparison to the NHANES Ⅱ, vitamin B_6 intake in this study was mainly composed of vitamin B_6 from plant sources. Though the amount of vitamin B_6 intake is adequate, this fact may affect the absorption and action of the vitamin in a body.

As for major dietary sources of vitamin B_6 (Table 4), the top 10 foods provided nearly 64% of total vitamin B_6, whereas there was about 48% of total vitamin B_6 in the NHANES Ⅱ. It can be indicated that dietary contributors of vitamin B_6 for Koreans are less varied than those for Americans. There is no the current literature on important food sources of vitamin B_6 in Korea. Therefore, the lists of major dietary contributors of vitamin B_6 reported in this study can provide the degree of detail necessary for use by nutritionists interested in assessing dietary vitamin B_6 intakes. Also, as the database on the bioavailability of vitamin B_6 from foods enlarges, the list of major food sources will aid in projecting estimates of bioavailable vitamins in the diet.

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