Potassium/Energy and Phosphorus/Calcium Ratios Reflect the Quality of Nutrition

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Abstract A nutritional survey and questionnaire regarding dietary habits were administered to 649 men ranging in age from 35 to 64 years receiving a one-day health screening examination. First, comparisons of nutrient intake based on the nutrient rate of the Recommended Dietary Allowances for Japanese (RDA), and the total score on the questionnaire regarding dietary habits according to the RDA rates of total energy and calcium (Ca) were investigated. Then, the comparisons of intake of food groups, intake of nutrients and the total score on the questionnaire regarding dietary habits according to potassium/energy (K/E) ratio and phosphorus/calcium (P/Ca) ratio were determined. Last, differences between comparisons with the nutrient rates of RDA and comparisons with K/E ratio and P/Ca ratio were investigated.

The following results were obtained:

1. Even in the group with RDA rates of total energy or Ca of $\geq 90\%$ and $\leq 110\%$ the RDA rates of some other nutrients were out-side the appropriate range.
2. In the group with high K/E ratios, as compared to the group with low ratios, the intake of potatoes, pulses, fruits, green/yellow vegetables, other vegetables, soy sauce, other beverages, fish/shellfish, and milk products showed high values, while cereals and fats/oils showed low values. For this reason, in the former group as compared to the latter, the intake and RDA total energy rate showed low values whereas the intake and RDA rates of nutrients such as Ca, Fe, and vitamin A were low.
3. In the group with high P/Ca ratios, as compared to the group with low ratios, the intake of beer and meats showed high values while that of pulses, green/yellow vegetables, and milk products showed low values. For this reason, in the former group as compared to the other groups, despite the fact that the intake and RDA total energy rate tended to be higher, the intake of nutrients such as Ca, P, K, and vitamin A showed lower values.
4. The RDA rates of all of the nutrients of group with a high K/E ratio and the group with a low P/Ca ratio generally showed largely appropriate values.
5. These results suggest that indices reflecting the balance of minerals such as the K/E and P/Ca ratios more objectively reflect the quality of nutrition than comparisons based on the RDA rates of total energy and specific-nutrient.

Key words : Potassium/energy ratio, Phosphorus/calcium ratio, Intake of nutrients, Intake of food groups, Nutrient rate of Recommended Dietary Allowances, Dietary habits

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Introduction

The steady intake of appropriate quantities of nutrients is indispensable for the maintenance and improvement of health as well as the prevention and treatment of various diseases. Parallel- ing the economic development of Japan in recent years, a diversity of food stuffs has become widely available, leading to what at first glance appears to be a marked improvement in the national diet. However, with the keeping of later hours and an increase in the number of persons living apart from their families, various diet-related problems, including late night eating, skipping of breakfast, and an increasing reliance on processed foods are becoming ever more serious^{1~3)}. Such dietary habits have contributed to a markedly disturbed balance of ingested nutrients, and it is speculated that even when the total energy intake itself is appropriate these habits may have a major impact on the balance of nutrients, particularly that of minerals, contained in the diet^{4~6)}.

In this regard, increasing attention has been focused on the relation between the unbalanced intake of minerals and the development of conditions such as taste disorders, osteoporosis, renal and ureteral stones, and ischemic heart disease^{7~10)}.

In the present study, on the basis of food diaries provided by persons attending a one-day health screening examination, the total energy (E) and calcium (Ca) intake rates of Recommended Dietary Allowances for Japanese (RDA) were determined. Then, the relationships between these two RDA rates and the intake and RDA rates of other nutrients as well as various dietary habits such as skipping meals, determined from a questionnaire administered at the same time, were investigated. However, it was considered difficult to evaluate the status of nutrient intake from the intake of total energy or single nutrients, so we focused on the ratios of potassium/total energy (K/E) and phosphorus/calcium (P/

Ca) intake. We investigated the relations between these ratios and the intakes of individual food groups and those of nutrients and RDA nutrient rates.

Materials and methods

Six hundred and forty-nine male civil servants ranging in age from 35 to 64 years who received a one-day health screening examination during the one-year period from April 1990 through March 1991 were studied. Table 1 shows the age distribution of these subjects. Prior to the health examination the subjects were given questionnaire forms on which they were asked to record the content of their diet during a 3-day period and, to answer a series of questions concerning their dietary habits, in particular those related to overeating, as listed in Table 2, and which they were asked to bring with them on the day of the health examination. A dietician then conducted direct interviews with each subject to confirm and revise the recorded diet content. After averaging the 3-day diet content, the total energy intake and amount of ingested nutri-

Table 1 Subjects investigated by age

Age	Number of subjects (%)
30~39	92 (14.2)
40~49	401 (61.8)
50~59	151 (23.3)
60~69	5 (0.8)
Total	649 (100.0)

Table 2 Questions regarding dietary habits

1. Are you uninterested in eating?	Yes	No
2. Do you tend to eat until becoming full?	Yes	No
3. Do you tend to eat quickly?	Yes	No
4. Do you sometimes omit breakfast?	Yes	No
5. Do you sometimes omit lunch?	Yes	No
6. Do you sometimes eat lunch after 2 PM?	Yes	No
7. Do you sometimes eat between meals?	Yes	No
8. Do you sometimes eat dinner after 8 PM?	Yes	No
9. Do you consume <50% of your daily intake at dinner time?	Yes	No
10. Do you sometimes snack at night?	Yes	No

ents were calculated referring to the 4th Revised Standard Tables of Food Composition in Japan¹¹⁾. In addition, the intake according to individual food groups was calculated based on the classification of the National Nutrition Survey¹²⁾. Also, when possible, the RDA nutrient rate was calculated by dividing the total energy intake and amount of each nutrient ingested by each subject by the corresponding RDA¹³⁾. At this time, in the case of allowances with a range of values, an intermediate value was adopted. On the questionnaire relating to dietary habits, answers indicating inappropriate and appropriate dietary habits were assigned scores of zero and one point, respectively, and the total score was calculated. With regard to questions 4 to 10, a frequency of three times per week or more was regarded as a positive answer.

Results

1. Division of groups according to the K/E ratio and P/Ca ratio

The K/E ratio was determined in each subject, and the subjects were divided into <25th percentile, 25-75th percentile, and ≥75th percentile groups. The group with low values of $<102.30 \times 10^{-2}$ (mg/kcal) was designated as Group A, that with high values of $\geq 135.6 \times 10^{-2}$ (mg/kcal) as Group C, and that with intermediate values as Group B.

Table 3 Comparison of body parameters according to the potassium/total energy (K/E) ratio

	Group A (n=162)	Group B (n=325)	Group C (n=162)
Age	44.5±6.2	45.3±5.7	46.7±5.9&&
Height (cm)	169.3±5.2	169.1±5.3	168.4±5.1
Weight (kg)	70.8±9.7	69.5±9.1	69.0±8.2
BMI (kg/m ²)	24.6±2.8	24.3±2.8	24.3±2.7

Mean±S.D.

&&: p<0.01, significant difference from Group A
Group A: the group with low K/E values of less than 102.30×10^{-2} (mg/kcal)
Group B: the group with intermediate K/E values
Group C: the group with high K/E values of more than 135.65×10^{-2} (mg/kcal)

Similarly, the subjects were divided into three groups according to the P/Ca ratio (<25th percentile, 25-75th percentile, and ≥75th percentile groups). The group with low values of <1.866 was designated as Group I, that with high values of ≥2.601 as Group III, and that with intermediate values as Group II.

Tables 3 and 4 show comparisons of physical parameters according to the K/E ratio and P/Ca ratio respectively. No differences in height, weight or body mass index (BMI) were noted between the groups divided according to either ratio, although a difference was seen in age. For this reason, comparisons of food intake groups and nutrient intake according to the K/E ratio and P/Ca ratio were made using two-way ANOVA with the K/E ratio or P/Ca ratio and age as factors to adjust the age. Then, for items showing significant differences among the three K/E ratio or P/Ca-ratio groups, differences between two of these groups were tested by using Scheffe's test¹⁴⁾.

2. Comparison of intake of nutrients, RDA nutrient rate and total score on the dietary habits questionnaire according to the RDA total energy rate and RDA Ca rate

The subjects were divided into three groups according to their total RDA energy rate (<90%, ≥90- ≤110%, >110%). They were similarly divided according to their RDA Ca rate.

Table 4 Comparison of body parameters according to the phosphorus/calcium (P/Ca) ratio

	Group I (n=163)	Group II (n=324)	Group III (n=162)
Age	46.8±6.2	45.4±5.9§	44.3±5.6&&
Height (cm)	168.9±5.5	168.9±5.4	169.3±4.6
Weight (kg)	69.2±9.2	69.3±9.1	70.9±8.7
BMI (kg/m ²)	24.3±2.9	24.2±2.7	24.7±2.8

Mean±S.D.

§: p<0.05, significant difference from Group I
&&: p<0.01, significant difference from Group I
Group I: the group with low P/Ca values of less than 1.866
Group II: the group with intermediate P/Ca values
Group III: the group with high P/Ca values of more than 2.601

Tables 5 and 6 show comparisons of physical parameters, intake of nutrients and RDA nutrient rates, and results of the questionnaire on dietary habits according to the RDA rates of total energy and Ca, respectively. These RDA rates were based on nutritional requirements determined taking into account the intensity of physical activity, age, and height. Here, one-way ANOVA was performed, and for items showing significant differences between the three groups comparisons between two of these groups were performed using Scheffe's test¹⁵⁾.

The intakes of total energy, protein, lipid, carbohydrate, Ca, P, K, sodium (Na), vitamin B1, and vitamin B2, and the RDA rates of pro-

tein, lipid, Ca, vitamin B1, and vitamin B2 all showed increasingly high values in the groups with higher RDA total energy rates (Table 5). The intake of iron in the group with a RDA total energy rate of >110% was higher than that of the other 2 groups. The intake of vitamin A in the group with a RDA total energy rate of >110% was higher than that of the group with a RDA total energy rate of <90%. In the total score on the dietary habits questionnaire the ≥ 90 - ≤ 110 % group showed higher values than the >110% group.

The intakes of energy, protein, lipid, Ca, P, K, vitamin A, vitamin B2, and vitamin C, and the RDA rates of total energy, protein, lipid, iron, vitamin A, vitamin B2 and vitamin

Table 5 Comparisons of intake of nutrients, RDA nutrient rate and dietary habits according to the RDA total energy rate

RDA total energy rate		<90% (n=258)	$\geq 90\%$, $\leq 110\%$ (n=270)	>110% (n=121)
Characteristics of participants				
Age	(Years)	45.3 $\pm$ 6.2	45.5 $\pm$ 5.7	45.7 $\pm$ 6.0
Height	(cm)	169.5 $\pm$ 5.1	169.0 $\pm$ 5.5	167.9 $\pm$ 4.8 ^b
Weight	(kg)	68.9 $\pm$ 8.6	69.7 $\pm$ 9.1	71.1 $\pm$ 9.7
BMI	(kg/m ²)	24.0 $\pm$ 2.6	24.4 $\pm$ 2.8	25.2 $\pm$ 2.9 ^{bbc}
Intake of nutrients				
Total energy	(kcal)	1710.4 $\pm$ 247.0	2083.6 $\pm$ 197.2 ^{aa}	2530.5 $\pm$ 319.9 ^{bbcc}
Protein	(g)	67.1 $\pm$ 13.0	80.3 $\pm$ 15.8 ^{aa}	96.1 $\pm$ 23.7 ^{bbcc}
Lipid	(g)	41.2 $\pm$ 11.8	52.0 $\pm$ 14.5 ^{aa}	64.3 $\pm$ 21.5 ^{bbcc}
Carbohydrates, non-fibrous	(g)	230.5 $\pm$ 43.4	271.7 $\pm$ 45.4 ^{aa}	323.1 $\pm$ 60.7 ^{bbcc}
Calcium	(mg)	446.7 $\pm$ 168.6	498.7 $\pm$ 181.8 ^{aa}	571.2 $\pm$ 224.6 ^{bbcc}
Phosphorus	(mg)	918.7 $\pm$ 193.7	1074.2 $\pm$ 224.3 ^{aa}	1267.6 $\pm$ 292.5 ^{bbcc}
Iron	(mg)	8.0 $\pm$ 2.0	9.2 $\pm$ 2.7	11.4 $\pm$ 12.5 ^{bbcc}
Potassium	(mg)	2210.0 $\pm$ 553.4	2497.0 $\pm$ 703.2 ^{aa}	2713.9 $\pm$ 706.2 ^{bbcc}
Sodium	(mg)	3872.9 $\pm$ 1291.9	4333.6 $\pm$ 1286.5 ^{aa}	4807.3 $\pm$ 1742.3 ^{bbcc}
Vitamin A	(IU)	1626.2 $\pm$ 1112.4	1862.9 $\pm$ 1304.3	1993.5 $\pm$ 1266.6 ^b
Vitamin B1	(mg)	0.74 $\pm$ 0.27	0.89 $\pm$ 0.30 ^a	1.11 $\pm$ 0.64 ^{bbcc}
Vitamin B2	(mg)	1.03 $\pm$ 0.35	1.18 $\pm$ 0.38 ^{aa}	1.46 $\pm$ 0.58 ^{bbcc}
Vitamin C	(mg)	68.6 $\pm$ 39.1	69.9 $\pm$ 34.4	72.2 $\pm$ 38.3
RDA nutrient rate				
Protein	(%)	93.1 $\pm$ 16.6	113.6 $\pm$ 21.3 ^{aa}	139.3 $\pm$ 32.6 ^{bbcc}
Lipid	(%)	75.9 $\pm$ 18.9	99.7 $\pm$ 25.5 ^{aa}	127.0 $\pm$ 39.5 ^{bbcc}
Calcium	(%)	71.3 $\pm$ 25.4	81.0 $\pm$ 28.7 ^{aa}	96.1 $\pm$ 38.6 ^{bbcc}
Iron	(%)	80.9 $\pm$ 19.6	94.3 $\pm$ 27.0 ^{aa}	107.3 $\pm$ 24.8 ^{bbcc}
Vitamin A	(%)	85.0 $\pm$ 59.4	94.3 $\pm$ 65.8	101.6 $\pm$ 63.3
Vitamin B1	(%)	94.9 $\pm$ 31.5	115.4 $\pm$ 32.3 ^{aa}	146.0 $\pm$ 74.7 ^{bbcc}
Vitamin B2	(%)	92.4 $\pm$ 26.0	110.0 $\pm$ 29.3 ^{aa}	138.5 $\pm$ 51.2 ^{bbcc}
Vitamin C	(%)	135.4 $\pm$ 73.4	140.5 $\pm$ 68.4	152.8 $\pm$ 84.4
Total score for dietary habits		6.6 $\pm$ 1.8	6.8 $\pm$ 1.9	6.2 $\pm$ 1.9 ^c

mean $\pm$ standard deviation

a: $p < 0.05$, aa: $p < 0.01$, significant difference from the <90% group

b: $p < 0.05$, bb: $p < 0.01$, significant difference from the <90% group

c: $p < 0.05$, cc: $p < 0.01$, significant difference from the $\geq 90\%$ and $\leq 110\%$ group

RDA: Recommended Dietary Allowances for Japanese

Table 6 Comparisons of intake of nutrients, RDA nutrient rate and dietary habits according to RDA Calcium rate

RDA calcium rate		<90% (n = 439)	≥90%, ≤110% (n = 127)	>110% (n = 83)
Characteristics of participants				
Age	(Years)	45.0±6.0	46.1±5.8	46.7±5.9
Height	(cm)	169.2±5.2	168.7±5.0	168.5±5.8
Weight	(kg)	69.5±8.9	70.1±8.5	69.6±10.4
BMI	(kg/m ²)	24.3±2.7	24.6±2.8	24.5±3.3
Intake of nutrients				
Total energy	(kcal)	1965.7±361.8	2070.3±380.0 ^a	2218.7±428.9 ^{bbc}
Protein	(g)	73.6±15.3	80.7±15.8 ^{aa}	96.9±30.8 ^{bbcc}
Lipid	(g)	47.1±16.7	53.2±17.0 ^{aa}	60.4±16.3 ^{bbcc}
Carbohydrates, non-fibrous	(g)	261.9±58.1	267.6±53.2	276.8±65.9
Calcium	(mg)	398.2±111.7	606.5±88.4 ^{aa}	809.3±199.5 ^{bbcc}
Phosphorus	(mg)	959.0±188.5	1139.1±184.8 ^{aa}	1383.0±350.0 ^{bbcc}
Iron	(mg)	8.2±1.9	9.5±2.2	13.2±15.0 ^{bbcc}
Potassium	(mg)	2230.5±480.7	2625.1±494.6 ^{aa}	3134.8±1099.0 ^{bbcc}
Sodium	(mg)	4182.6±1405.8	4406.4±1452.2	4279.6±1474.2
Vitamin A	(IU)	1618.0±1157.4	1976.5±1148.6 ^a	2438.8±1464.8 ^{bbc}
Vitamin B1	(mg)	0.83±0.34	0.88±0.29	1.06±0.69 ^{bbcc}
Vitamin B2	(mg)	1.04±0.33	1.33±0.34 ^{aa}	1.65±0.65 ^{bbcc}
Vitamin C	(mg)	63.2±32.4	75.5±33.6 ^{aa}	96.0±50.1 ^{bbcc}
RDA nutrient rate				
Total energy	(%)	92.2±16.6	98.9±18.3 ^{aa}	106.5±21.4 ^{bbcc}
Protein	(%)	103.4±20.8	114.9±21.4 ^{aa}	139.4±44.2 ^{bbcc}
Lipid	(%)	88.8±30.8	103.9±31.1 ^{aa}	116.6±30.1 ^{bbc}
Iron	(%)	84.0±19.1	98.9±21.1 ^{aa}	119.4±38.0 ^{bbcc}
Vitamin A	(%)	83.6±60.7	100.3±56.9 ^a	123.8±72.8 ^{bbc}
Vitamin B1	(%)	107.2±38.0	116.3±34.6	138.6±83.2 ^{bbcc}
Vitamin B2	(%)	95.8±26.4	122.5±25.5 ^{aa}	152.6±55.3 ^{bbcc}
Vitamin C	(%)	126.8±62.8	155.1±71.2 ^{aa}	192.5±100.3 ^{bbcc}
Total score for dietary habits		6.6±1.8	6.7±1.9	6.5±1.9

mean±standard deviation

^a: p<0.05, ^{aa}: p<0.01, significant difference from the <90% group^b: p<0.05, ^{bb}: p<0.01, significant difference from the <90% group^c: p<0.05, ^{cc}: p<0.01, significant difference from the ≥90% and ≤110% group

RDA: Recommended Dietary Allowances for Japanese

C rates all showed increasingly high values in the groups with higher RDA Ca rates (Table 6). The intakes and RDA rates of iron and vitamin B1 showed higher values in the group with a RDA Ca rate of >110% as compared to the other 2 groups. However, the total score on the dietary habits questionnaire did not differ among the three groups.

3. Comparison of intake of food by food groups according to the K/E ratio and P/Ca ratio

As shown in Table 7, in the comparison of the K/E ratio, in Group C with the other two groups, the intake of potatoes, pulses, fruits, green/yellow vegetables, other vegetables, soy sauce, other beverages, fish/shellfish, and milk

products was high, while that of cereals and fats/oils was low.

Although not shown in the Table, the energy intake according to food groups also showed high values in Group C for potatoes, pulses, fruits, green/yellow vegetables, soy sauce, and fish and shellfish, and low values for cereals and fats/oils, with these results virtually the same as those of the study on intake according to food groups.

As shown in Table 8, in Group I, with a low P/Ca ratio, as compared to the other two groups, the intake of cereals was low, while that of pulses and milk products was high. In contrast, in Group III with a high P/Ca ratio, as com-

Table 7 Comparison of intake of foods by food groups according to the K/E ratio (g/day)

	Group A	Group B	Group C
Cereals	657.5	587.1 ^{\$\$}	489.9 ^{&&¥¥}
Nuts and Seeds	0.8	1.7	0.8
Potatoes	25.6	36.3 ^{\$}	52.0 ^{&&¥¥}
Sugars	8.6	7.4	6.6
Confectioneries	10.0	7.1	5.9
Fats and Oils	17.6	14.0 ^{\$\$}	10.2 ^{&&¥¥}
Pulses	73.8	89.5	117.1 ^{&&¥¥}
Fruits	37.1	71.0 ^{\$\$}	96.3 ^{&&¥}
Green yellow Vegetables	53.0	74.4 ^{\$\$}	117.7 ^{&&¥¥}
Vegetables, others	121.4	144.7 ^{\$\$}	172.2 ^{&&¥¥}
Fungi	4.2	5.2	6.9 ^{&}
Algae	4.4	6.4	8.5 ^{&&}
Soy-sauce	14.4	16.0	21.0 ^{&¥}
Worcester-sauces	2.9	2.0	2.0
Salts	1.5	1.5	1.5
Sake	121.3	80.8 ^{\$\$}	48.6 ^{&&¥}
Beer	272.0	281.6	292.0
Alcoholic beverages	13.6	10.4	8.8
Beverages, others	190.9	222.5	313.0 ^{&&¥¥}
Fishes and shellfishes	107.5	123.3	146.8 ^{&&¥¥}
Meats	70.8	52.6 ^{\$\$}	46.2 ^{&&}
Eggs	35.7	34.8	30.0
Milk products	82.4	134.1 ^{\$\$}	170.0 ^{&&¥¥}
Prepared foods	1.1	1.2	1.5

figures are means after adjusting for age according to two-way analysis of variance

^{\$}: p<0.05, ^{\$\$}: p<0.01, significant difference from Group A

[&]: p<0.05, ^{&&}: p<0.01, significant difference from Group A

[¥]: p<0.05, ^{¥¥}: p<0.01, significant difference from Group B

Table 8 Comparison of intake of foods by food groups according to the P/Ca ratio (g/day)

	Group I	Group II	Group III
Cereals	527.4	594.7 ^{\$\$}	605.0 ^{&&}
Nuts and Seeds	1.3	1.4	1.0
Potatoes	39.2	38.5	33.9
Sugars	7.1	7.0	8.8
Confectioneries	8.6	7.1	7.1
Fats and Oils	12.9	13.8	15.1
Pulses	122.8	94.7 ^{\$\$}	57.5 ^{&&¥¥}
Fruits	81.5	63.6	66.5
Green yellow Vegetables	96.8	81.3	60.0 ^{&&¥}
Vegetables, others	149.5	147.3	138.8
Fungi	5.7	4.9	5.8
Algae	8.0	6.7	4.2 ^{&&¥}
Soy-sauce	15.1	18.0	16.3
Worcester-sauces	1.7	2.2	2.8
Salts	1.2	1.6 ^{\$}	1.6 ^{&}
Sake	77.9	86.0	81.6
Beer	194.3	273.5	386.4 ^{&&¥¥}
Alcoholic beverages	9.8	9.0	15.5
Beverages, others	250.6	240.8	216.5
Fishes and shellfishes	112.5	128.5 ^{\$}	131.4 ^{&}
Meats	40.6	51.8	78.2 ^{&&¥¥}
Eggs	29.5	34.8	37.3 ^{&}
Milk products	228.0	126.2 ^{\$\$}	39.7 ^{&&¥¥}
Prepared foods	1.1	1.3	1.3

figures are means after adjusting for age according to two-way analysis of variance

^{\$}: p<0.05, ^{\$\$}: p<0.01, significant difference from Group I

[&]: p<0.05, ^{&&}: p<0.01, significant difference from Group I

[¥]: p<0.05, ^{¥¥}: p<0.01, significant difference from Group II

pared to the other groups, the intake of pulses, green/ yellow vegetables, and milk products was low, while that of beer and meat was high.

In the comparison of the energy intake according to food groups (data not shown in the Table) as well, Group I showed low values for cereals and high values for milk products as compared to the other groups, whereas Group III showed low values for pulses, green/yellow vegetables, and milk products and high values for beer and meat.

4. Comparison of the total energy intake, nutrient intake, RDA nutrient rate and the total score of the dietary habits questionnaire according to the K/E ratio and P/Ca ratio

As shown in Table 9, in Group C with a high K/E ratio, despite the fact that the total energy intake was low as compared to the other two groups, the intake of nutrients such as Ca, P, and vitamin A was higher. On the other hand, in Group A with a low K/E ratio, the intake of

lipids and carbohydrates was high as compared to the other two groups, and so the total energy intake was also higher, although, conversely, the Ca intake was lower.

In the study on the RDA rate of each nutrient as well, the total energy rate in group C was low as compared to the other two groups, whereas the rates of other nutrients such as Ca, Fe and vitamin A were high, these results being similar to those of the study on nutrient intake.

Furthermore, in the comparison of the total score of the dietary habits questionnaire, Groups B and C showed higher scores than Group A.

As shown in Table 10, in Group I with a low P/Ca ratio, total energy intake was low as compared with Group III, whereas the intake of nutrients such as Fe, K, and vitamin A was high. In the comparison of Groups I and II as well, although total energy intake was lower in the former, the intake of Ca, vitamin B2 and vitamin C was higher. On the other hand, in the compar-

Table 9 Comparison of intake of nutrients, RDA nutrient rate and dietary habits according to the K/E ratio

		Group A	Group B	Group C
Intake of nutrients				
Total energy	(kcal)	2177.2	2010.1 \$\$	1877.0 &&¥¥
Potassium	(mg)	1946.6	2378.9 \$\$	2989.2 &&¥¥
Protein	(g)	76.4	76.8	81.8 ¥
Lipid	(g)	53.9	49.2 \$	47.6 &&
Carbohydrates, non-fibrous	(g)	285.7	265.7 \$\$	242.5 &&¥¥
Calcium	(mg)	398.5	490.3 \$\$	586.9 &&¥¥
Phosphorus	(mg)	970.7	1042.8 \$	1127.5 &&¥¥
Iron	(mg)	8.8	8.7	10.1
Vitamin A	(IU)	1535.1	1744.1	2149.4 &&¥¥
Vitamin B1	(mg)	0.9	0.8	0.9
Vitamin B2	(mg)	1.0	1.2 \$	1.3 &&¥¥
Vitamin C	(mg)	47.8	69.9 \$\$	91.6 &&¥¥
RDA nutrient rate				
Total energy	(%)	102.4	95.0 \$\$	89.0 &&¥¥
Protein	(%)	109.3	108.4	114.9 ¥
Lipid	(%)	103.4	93.6 \$\$	91.0 &&
Calcium	(%)	67.0	79.3 \$\$	94.2 &&¥¥
Iron	(%)	83.2	89.8 \$	102.8 &&¥¥
Vitamin A	(%)	79.8	90.4	108.2 &&¥
Vitamin B1	(%)	115.7	110.0	116.1
Vitamin B2	(%)	97.7	107.5 \$	120.6 &&¥¥
Vitamin C	(%)	100.9	139.6 \$\$	182.9 &&¥¥
Total score for dietary habits		6.2	6.7 \$	6.8 &

figures are means after adjusting for age according to two-way analysis of variance

\$: $p < 0.05$, \$\$: $p < 0.01$, significant difference from Group A

&: $p < 0.05$, &&: $p < 0.01$, significant difference from Group A

¥: $p < 0.05$, ¥¥: $p < 0.01$, significant difference from Group B

RDA: Recommended Dietary Allowances for Japanese

Table 10 Comparison of intake of nutrients, RDA nutrient rate and dietary habits according to the P/Ca ratio

		Group I	Group II	Group III
Intake of nutrients				
Phosphorus	(mg)	1103.2	1051.3 ^{\$\$}	987.6 ^{&&¥¥}
Calcium	(mg)	676.1	486.8 ^{\$\$}	315.4 ^{&&¥¥}
Total energy	(kcal)	1939.0	2030.7 ^{\$}	2074.5 ^{&}
Protein	(g)	76.2	78.7	78.3
Lipid	(g)	50.5	49.9	49.8
Carbohydrates, non-fibrous	(g)	254.6	268.0	269.0
Iron	(mg)	10.2	9.0	8.2 ^{&&}
Potassium	(mg)	2532.6	2456.6	2246.9 ^{&&¥¥}
Vitamin A	(IU)	1967.5	1853.8	1496.4 ^{&&¥}
Vitamin B1	(mg)	0.9	0.9	0.9
Vitamin B2	(mg)	1.3	1.2 ^{\$}	1.1 ^{&&}
Vitamin C	(mg)	79.4	68.7 ^{\$}	62.5 ^{&&}
RDA nutrient rate				
Total energy	(%)	92.3	95.9	97.3 ^{&}
Protein	(%)	107.9	111.2	110.7
Lipid	(%)	96.8	94.8	95.0
Calcium	(%)	107.7	79.0 ^{\$\$}	54.0 ^{&&¥¥}
Iron	(%)	96.2	92.5	84.4 ^{&&¥¥}
Vitamin A	(%)	101.5	95.1	76.3 ^{&&¥¥}
Vitamin B1	(%)	113.6	110.8	116.7
Vitamin B2	(%)	117.0	107.9	100.5 ^{&&}
Vitamin C	(%)	160.9	137.8 ^{\$\$}	126.3 ^{&&}
Total score for dietary habits		6.7	6.7	6.3

figures are means after adjusting for age according to two-way analysis of variance

^{\$} : $p < 0.05$, ^{\$\$} : $p < 0.01$, significant difference from Group I

[&] : $p < 0.05$, ^{&&} : $p < 0.01$, significant difference from Group I

[¥] : $p < 0.05$, ^{¥¥} : $p < 0.01$, significant difference from Group II

RDA : Recommended Dietary Allowances for Japanese

ison of Groups II and III, no differences were found in the intake of energy while the intake of K and vitamin A was higher in the former.

Looking at these RDA nutrient rates, the total energy rate of Group I was lower than that of Group III. Conversely, those of nutrients such as iron and vitamin A were higher, showing a tendency similar to the results of the comparison of intake of nutrients.

However, no significant differences were found among the three groups in the total score of the dietary habits questionnaire.

Discussion

Reflecting the recent economic development of Japan the dietary circumstances of the people have undergone rapid change. On the one hand, a wide variety of foods has become readily available, while on the other the number of consumed foods has decreased because the taking of meals has become irregular, the consumption of

animal and processed foods has increased, and mealtimes have become shorter, with these factors giving rise to an imbalance in the intake of nutrients^{1~3)}.

The authors previously investigated the influence exerted by poor dietary habits such as skipping meals and late-night eating on obesity and the intake of each kind of nutrient in the same population studied here^{16, 17)}. Our results revealed that in the group with poor dietary habits, the proportion of overweight persons was greater than that in the group with good dietary habits¹⁶⁾. However, even when many poor dietary habits were present but the total energy intake was within or below the suitable range, obesity did not develop, although an influence on the intake of other nutrients was observed¹⁷⁾. Shiraki et al.¹⁸⁾ similarly reported that in groups with the same total energy intake, such poor dietary habits had a major influence on the unbalanced intake of minerals. That is, over consumption

of animal and processed foods leads to excessive consumption of P. Insufficient consumption of vegetables and fruits associated with a decrease in the number of foods selected results in a decrease in the amount of K consumed, and moreover, insufficient consumption of milk products and small fish leads to inadequate Ca consumption. In this way, it was thought that the balance of intake of minerals suggests the quality of nutrition. In a recent National Nutrition Survey¹⁹⁾ as well, the intake of nutrients such as Ca and Fe was noted to be insufficient and to require particular attention in the diet.

At first, based on the conventionally used RDA nutrient rates^{20, 21)}, we performed comparisons of the intake and nutrients rates according to RDA rates of total energy or Ca. Comparisons according to the RDA energy rate were indeed effective for investigating the relation between RDA total energy rate and BMI and between RDA total energy rate and the total score on the dietary habits questionnaire. However, although none of the water-soluble RDA vitamins rates in the group showed an appropriate RDA total energy rate of ≥ 90 , the $\leq 110\%$ group showed less than 100%, the RDA protein rate was 113.6% and that of Ca 81%, both of which were clearly less than desirable (Table 5). On the other hand, comparing the RDA Ca rate as well, the RDA protein rate was 114.9% even in the groups with RDA Ca rates ≥ 90 and $\leq 110\%$. The influence of low Ca intake has already been demonstrated⁸⁾, and it is also known that a high protein intake enhances the urinary excretion of Ca, leading to a negative Ca balance²²⁾. These results suggest that studies focusing on the intake of total energy alone or individual nutrients may be inadequate.

Based on above results, we performed a study of groups divided according to K/E ratio and P/Ca ratio. Group C with a high K/E ratio showed less consumption of cereals, fats/oils, and Japanese rice wine and more consumption of pulses and vegetables as compared to Group

A with a low K/E ratio. As a result, although the RDA protein rate of Group C was high, this group showed an appropriate intake of vitamins and minerals and a dietary content markedly more favorable than that of Group A with a low K/E ratio. The total score on the dietary habits questionnaire also showed higher values in this group (Tables 7, 9). Group I with a low P/Ca ratio, as compared to Group III with a high P/Ca ratio, showed higher consumption of pulses, vegetables, and milk products and lower consumption of cereals, meat, and beer. As a result, the total score on the dietary habits questionnaire did not differ among the three groups because the questions on it were mostly related to over-eating. However, a favorable balance of food groups and nutrients was confirmed in Group I, which showed values for all items within 10% of desirable values. Also, as compared to the differences of the RDA rates of total energy, protein and lipid in the three groups divided according to the P/Ca, those in minerals and vitamins were considerably more striking (Table 8, 10).

From the above results it was surmised that the K/E ratio reflects the balance of nutrient intakes, taking into account total energy intake, while the P/Ca ratio reflects the balance of mineral intake without being unduly influenced by the total energy intake.

It has been recognized that the unbalanced intake of nutrients over protracted periods is a risk factor for various adult diseases²³⁾. It is necessary to again recognize that, for a nutrient to be properly taken up and used by the body, numerous other nutrients play a role, with the health of the body maintained by the interactions among these nutrients. For this reason, it is important that excessive reliance not be placed on fast and processed foods, and that as many different kinds of foods as possible be consumed at the appropriate times and in appropriate amounts.

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