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A Study on the Riboflavin Nutritional Status by Biochemical Tests in Healthy Female College Students in Korea*

Il Eun Lee and Hee Young Paik

Department of Food and Nutrition, Dongnam Health Junior College and Department of Food and Nutrition, Sookmyung Women's University

生化學的 測定方法에 의한 우리나라 女大生들의 리보플라빈 營養狀態에 관한 研究

李 一 恩 · 白 喜 英

東南保健專門大學 食品營養學科

淑明女子大學校 食品營養學科

□ 요 약 □

본 연구는 우리나라 여대생들의 riboflavin (RF) 영양상태를 평가하기 위하여 서울거주 여대생 48명 (정상식이를 하는 학생 31명과 lacto－ovo vegetarian 인 학생 17명) 을 대상으로 식이섭취조사, 임상검사, EGRAC 검사 및 소변검사를 실시하여 다음과 같은 결과를 얻었다.

1. 본 조사 대상 학생들은 동연령층에 대한 한국인 영양권장량에 비하여 열량섭취량은 낮고, 단백질 섭취량은 비슷하나 리보플라빈 섭취량은 높았다. 채식군의 학생들은 정상식이군에 비하여 열량과 단백질 섭취량은 낮았으나 리보플라빈 섭취량은 정상식이군과 비슷하였다.

2. 전 대상자들의 평균 EGRAC 값은 1.24±0.03이었으며, 정상식이군은 1.19±0.04, 채식군은 1.32±0.06으로 두 군의 평균값은 0.05수준에서 유의적 차이가 없었다. ERGAC 값이 1.2이상인 대상자는 전 대상자 중 65%이었는데 정상식이군은 55%, 채식군은 82%이었다.

3. EGRAC 값이 1.2이상인 대상자 중 18명에게 1일 5mg 의 리보플라빈을 1주일간 투여한 후 재검사한 결과 모두 1.2이하로 감소하였다.

4 상관분석 결과, 대상자들의 EGRAC값과 리보플라빈식이 섭취량 사이에는 유의적인 상관관계가 없었다. 이와 같은 결과가 나온 가능한 이유들에 대하여 고찰하였다.

이러한 결과들로 부터 본 조사 대상자들은 리보플라빈 섭취량은 한국인 영양권장량보다 높으나 생화학적 기능의 손상이 비교적 높은 비율로 존재함을 알 수 있다. 따라서 리보플라빈 식이섭취량이 낮은것으로 보고된 다른 집단들에 대하여 좀 더 집중적인 연구가 요청된다.

아직 우리나라 사람들을 대상으로 리보플라빈 식이섭취와 생화학적 결핍에 대하여 연구된 바가 적으므로 리보플라빈의 생화학적 결핍판정과 한국인의 RDA 수준에 대하여 더 많은 연구가 요청된다.

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ABSTRACT

A dietary survey by 3-day food record, clinical examination, urinary riboflavin excretion, and erythrocyte glutathione reductase activity coefficient (EGRAC) were measured on forty-eight female college students residing in Seoul. Thirty-one students were on normal diet and seventeen were lacto-ovo vegetarians. The results are as following : (1) Students had lower intakes of energy, similar intakes of protein and higher intake of riboflavin compared to Korean RDA for their age group. Vegetarians were lower in energy and protein intakes but were similar in RF compared to omnivores. (2) Mean EGRAC values were 1.24± 0.03 for all subjects, 1.19 ± 0.04 for omnivores, and 1.32±0.06 for vegetarians. Percentages of subjects with EGRAC values above 1.2 were 65 % in all subjects, 55% in omnivores, and 82% in vegetarians. Therefore, it was concluded that vegetarians were more severe in biochemical lesions than omnivores despite the fact that their RF intakes were similar to omnivores. (3) Eighteen students who had EGRAC values above 1.2 were given daily supplementation of 5mg RF for one week and EGRAC determination was repeated. They all returned to normal range. (4) Correlation analyses showed that there was no significant correlation between the EGRAC values and dietary intakes of nutrients. Possible explanations for this were given. From these results, it was concluded that even though dietary RF intakes of the subjects were higher than Korean RDA levels, biochemical deficiency among the subjects was remarkably high if the criteria of EGRAC > 1.2 were used. More investigations are necessary to establish a criteria for biochemical deficiency and RDA levels of riboflavin for Koreans.

KEY WORDS: Riboflavin intake · Riboflavin requirement · Urinary riboflavin · erythrocyte glutathione reductase activity coefficient · vegetarians.

INTRODUCTION

Utilization of erythrocyte glutathione reductase in assessment of riboflavin (RF) nutriture has provided a fast, convenient and reliable index to reflect the biochemical function of this vitamin of an individual[1-4]. Many recent reports[5)-10)] have repeatedly shown that erythrocyte glutathione reductase activity coefficient (EGRAC) which is determined by the degree of stimulation of EGR by addition of FAD in vitro can be used for evaluation of RF nutritional status either by alone or in combination with other methods such as urinary RF excretion and dietary survey.

Several reports have shown that subjects with adequate dietary RF intake compared to RDA and no apparent clinical signs of RF deficiency have biochemical lesions when EGRAC values are determined[5)6)]. These biochemical lesions usually disappear when RF supplementation exceeding RDA levels is given. Consequently, there has been a controversy on whether present RDA level should be reconsidered.

RF is reported to be one of the most limiting nutrients in many dietary surveys conducted in Korea. In National Nutrition Survey 1982-1983[11)] the average RF intake level was 70.5% of Korean RDA in the whole country[12)]. Angular somatitis was observed in 1.98 % of the total subjects, the prevalence being the highest in children of age 5-14 years (3.04%). Other reports[13)14)] show that several groups have especially low intakes of RF. Preschoolers and population with low socioeconomic status were consuming only 62.5-76% of RDA levels of their groups. Studies on female college students in urban area show that RF intake levels in this population are more favorable. Lee[15)] reported that daily RF intake was 1.07mg (89% of RDA) and Lee and Moon[16)] estimated it to be 1.6-2.2mg which is much higher than RDA (1.2 mg/day). According to the National Nutrition Survey of 1982-1983[11)], the prevalence rates of angular somatitis in females of 15–19 years and 20–24 years of age were 1.27% and 1.07% respectively. Reports on biochemical assessment of RF nutriture of Koreans are scarce. Tchai[17] conducted study on EGRAC values of 15 male and 12 female healthy college students. Mean ERGAC values were 1.35 for males and 1.33 in females, both are significantly higher than 1.2, the generally accepted value to determine RF deficiency. Report by Kim[18] show that mean EGRAC values of 50 healthy nonpregnant women in Korea was 1.428 and that of 50 pregnant women was 1.638. The numbers of subjects with EGRAC value above 1.2 were 43 among nonpregnant women and 46 among pregnant women, the prevalence being 86% and 92 % respectively. Therefore, it seems that even though dietary intake levels of RF among adult females are reportedly adequate, the prevalence of marginal deficiency could be quite high.

Present study was conducted to evaluate the RF nutritional status of female college students more systematically. Dietary survey by 3-day dietary record, clinical examination and EGRAC were performed on each of 48 subjects ; 31 on normal diet and 17 on lacto-ovo vegetarian diet. Urinary RF excretion was determined on some subjects. Since this population has been reported to have higher dietary RF intakes and lower incidence of clinical symptoms of RF defieiency, any sign of biochemical lesions in this group would indicate that lesions of other groups could be even more severe. Also the results from this study could be useful in establishing Korean RDA for adult females.

MATERIALS AND METHODS

Subjects The study was performed on forty-eight apparently healthy female college students of age 18–25 years who were not on regular vitamin supplementation. Thirty-one students were on normal diet and seventeen students were Seventh-Day Adventists and had been lacto-ovo vegetarians for most of their lives. For each subject, dietary survey by 3-day record and clinical examination for angular somatitis and cheilosis were conducted at the time of blood sampling. Urine samples were also collected on some of the subjects. Fasting blood samples were collected in tubes containing EDTA (1mg/ml blood) as anticoagulant and EGRAC values were determined following the methods described by Sauberlich, et al[4].

Riboflavin Supplementation To students who had EGRAC values above 1.2 and agreed to take RF supplementation, daily supplement of 5 mg RF was given for one week. After the supplementation period, EGRAC test was repeated to see whether the biochemical lesions had been corrected. RF used in the study was kindly provided by the Yuhan Research Center, Yuhan Corp., in Seoul, Korea.

Urinary RF Excretion Urine specimen was collected from twenty-five students and RF and creatinine contents of urine were determined. Creatinine was determined by Jaffe modified method using creatinine kit (BC 106, Yeong Dong Pharmaceutical Corp., Seoul, Korea). Urinary RF was determined by lumiflavin method described by Pearson[19] using Fluorescence Spectrophotometer (Hitachi 650-40). Urinary RF determination was repeated on 10 students after RF supplementation.

Statistical Analyses Data obtained were treated statistically and the significance of difference between the two means was determined by Student's t-test. Multiple correlation and regression analyses were performed using SPSS package to dedermine whether there exist any relationships among EGRAC values, dietary intake, and urinary RF excretion of the subjects.

RESULTS

Physical measurements, dietary intake data, and EGRAC values of the subjects are summarized in Table 1. Mean values of age, height, and weight were not significantly different between the two groups although vegetarians tended to be shorter and lighter than omnivores Energy and protein intakes of omnivores were significantly higher than vegetarians. Both groups were low in energy intakes but protein intake was low only in vegetarians compared to Korean RDA. Daily intake of RF in two groups were very similar and higher than Korean RDA level of 1.2mg per day. However, RF intake per 1,000 Calorie was higher in vegetarians because energy intake in this group was lower than omnivores. None of the students had any observable clinical signs of RF deficiency. Mean EGRAC values of the two groups were not significantly different (P > .05) but vegetarians had higher mean value than omnivores, indicating that they could be in less favorable RF nutriture. Overall, mean EGRAC values on total subjects and in vegetarians were higher than 1.2, the generally accepted criteria for biochemical lesions, and that in omnivores is very close to the cutoff value. Distribution of students according to their EGRAC values is shown in Figure 1. Using the criteria

Table 1. Physical measurement, nutrient intake and EGRAC* value of subjects

	Omnivores (n= 31)	Vegetarians (n= 17)	All Subjects (n= 48)
Age (yr)	21.32±0.47 **	20.76± 0.27	20.48 ±0.32
Height (cm)	160.11±0.90	157.35± 1.04	159.16 ±0.71
Weight (kg)	52.06± 1.02	49.44± 1.11	51.14± 0.78
Energy (kcal/day)	1,682.8±51.0+	1,300.8 ± 40.8	1,547.5 ±39.0
	(84.1)‡	(65.0)	(77.4)
Protein (g/ day)	70.0±2.6 +	51.7 ± 1.4	63.5 ±1.9
	(100.0)	(73.9)	(90.7)
Riboflavin (mg/ day)	1.40 ±0.06 +	1.47 ± 0.05	1.43 ±0.04
	(116.7)	(122.5)	(119.2)
Riboflavin (mg/ 1,000 kcal)	0.85 ±0.03	1.16 ± 0.05	0.96 ±0.03
	(141.7)	(193.3)	(160.0)
EGRAC	1.19 ±0.04	1.32 ± 0.06	1.24 ±0.03

* EGRAC means erythrocyte glutathione reductase activity coefficient.
** Mean±SEM
+ Mean values of the two groups are significantly different (P < 0.05).
‡ Values in parentheses represent % RDA.

Table 2. Nutrient intakes of groups divided by EGRAC values

Group	Energy (kcal/ day)	Protein (g/ day)	Riboflavin (mg/ day)	Riboflavin (mg/ 1,000 kcal)
EGRAC < 1.2 (n= 17)	1.606±75.6* (80.3)+	68.7±4.8 (98.1)	1.55±0.13 (129.2)	0.96±0.07 (160.0)
EGRAC >1.2 (n= 31)	1.515±60.8 (75.8)	60.7±2.5 (86.7)	1.36±0.06 (113.3)	0.95±0.05 (158.3)
All Subjects (n= 48)	1.548±39.0 (77.4)	63.5±1.9 (90.7)	1.43±0.04 (119.2)	0.96±0.03 (160.0)

* Mean±SEM.
+ Values in parentheses represent % RDA.

of EGRAC > 1.2, 55% of omnivores (17/31) and 82 % in vegetarians (14/17) were deficient in RF. The overall prevalence of RF deficiency was 64%.

Nutrient intakes of subjects with EGRAC values above and below 1.2 are compared in Table 2. Subjects with better RF nutriture (EGRAC < 1.2) had higher intakes of energy, protein, and RF but the differences were not statistically significant.

Of the thrity-one students with EGRAC values higher than 1.2, eighteen students were given daily supplementation of 5mg RF for one week. RF intake at the time of first EGRAC test and EGRAC values before and after RF supplementation of the 18 subjects are summarized in Table 3. Their dietary intake of RF was apparently higher than RDA level. All the subjects returned to normal after RF supplementation indicating that they had biochemical lesions initially. Correlation analyses showed no significant correlation between EGRAC values of the students tested and their dietary factors (Table 4).

Urinary RF excretion among the subjects showed a great variability ranging from 14.5 μg to 2,292.3 μg per gram creatinine (See Table 5). Of the 25 students at initial blood sampling, 7 students had urinary RF level below 80 μg/g creatinine, the generally accepted criteria for normal adults[20]. Therefore, the prevalence of RF deficiency based on urinary RF excretion was 28%, a much lower level than when EGRAC was used. Urinary RF excretion of ten students tested after RF supplementation showed a general increase even though a great variability still existed. None of the ten students had urinary RF below 80μg/g creatinine. There was a significant difference between the sample means of 25 students tested initially and

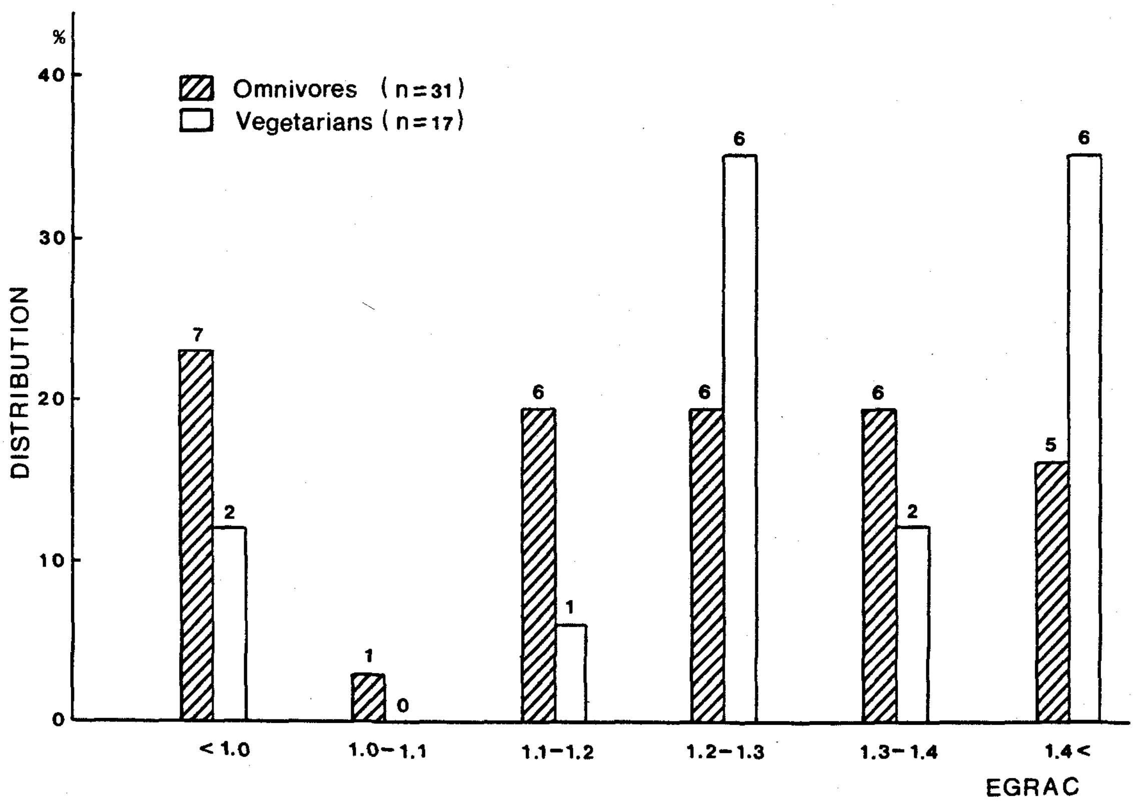

Fig. 1. Percent distribution of students according to EGRAC values.
EGRAC values above 1.2 are considered to indicate riboflavin deficiency.
Numbers on each bar represents the number of students.

Table 3. Riboflavin intake and EGRAC values of students given supplementation

No.	Group	Riboflavin (mg/day)	EGRAC	
			Before supplementation	After supplementation
1	Omnivores	1.31± 0.25*	1.24±0.13	0.97±0.03
2	〃	1.65± 0.04	1.31±0.13	0.94±0.01
3	〃	1.22± 0.42	1.36±0.12	0.92±0.01
4	〃	1.42± 0.20	1.23±0.10	1.03±0.09
5	〃	1.40± 0.08	1.49±0.17	1.05±0.05
6	〃	1.52± 0.11	1.46±0.06	1.03±0.02
7	〃	0.85± 0.24	1.34±0.11	0.94±0.07
8	〃	1.32± 0.23	1.40±0.18	0.92±0.01
9	〃	1.14± 0.23	1.22±0.10	0.97±0.07
10	Vegetarians	1.50± 0.16	1.68±0.21	1.20±0.10
11	〃	1.50± 0.16	1.24±0.04	1.18±0.05
12	〃	1.50± 0.16	1.58±0.21	0.95±0.06
13	〃	1.03± 0.11	1.34±0.10	1.20±0.24
14	〃	2.18± 0.35	1.21±0.07	1.11±0.21
15	〃	1.50± 0.16	1.28±0.10	1.10±0.20
16	〃	1.01± 0.11	1.38±0.06	0.95±0.15
17	〃	1.50± 0.16	1.58±0.23	0.91±0.06
18	〃	1.31± 0.03	1.27±0.04	0.90±0.17
All Subjects		1.38± 0.07	1.37±0.03	1.02±0.02

* Mean±SEM.

Table 4. Correlation coefficients between nutrient intakes and EGRAC of subjects (n=48)

	Energy (kcal/day)	Protein (g/day)	Riboflavin (mg/day)	Riboflavin (mg/1,000 kcal)	EGRAC
Energy (kcal/day)	1.00000 (0.0000)*	0.77301 (0.0001)	1.29029 (0.0451)	-0.42059 (0.0029)	-0.09417 (0.5244)
Protein (g/day)	0.77301 (0.0001)	1.00000 (0.0000)	0.37133 (0.0094)	- 0.24230 (0.0971)	-0.19244 (0.1901)
Riboflavin (mg/day)	0.29059 (0.0451)	0.37133 (0.0094)	1.00000 (0.0000)	0.71435 (0.0001)	-0.18569 (0.2064)
Riboflavin (mg/1000 kcal)	- 0.42059 (0.0029)	-0.24230 (0.0971)	0.71435 (0.0001)	1.00000 (0.0000)	-0.03822 (0.7965)
EGRAC	- 0.09417 (0.5244)	-0.19244 (0.1901)	-0.18569 (0.2064)	- 0.03822 (0.7965)	1.0000 (0.0000)

* Values in the parentheses are p-values.

Table 5. Urinary riboflavin excretion of Omnivorous students

Initial Testing			After Riboflavin Supplementation
EGRAC >1.2 (n= 14)	EGRAC < 1.2 (n=11)	Total (n= 25)	(n= 10)
133.1±26.8* (14.5 - 394.6)‡	338.2±197.6 (52.6 - 2,292.3)	223.3±88.4+ (14.5 - 2,292.3)	952.0±535.3+ (93.3 - 5,625.0)

* Mean± SEM.
\+ Mean values of the two groups are significantly different($p < 0.025$).
‡ Range of values.

ten students tested after RF supplementation ($P < .025$). Correlation coefficient between the EGRAC values and urinary RF excretion among the 25 students tested initially was -0.2081, not significant at the level of $P < .05$.

DISCUSSION

The average height and weight of the students in the present study are comparable to the national average for the same age group as reported in the National Nutrition Survey, 1982-83[11]. Vegetarians were shorter and lighter than omnivores and this is similar to the reports by Sacks et al[21] Energy intakes in these students were lower than RDA level of 2,000 kcal for adult females as shown in many previous reports both in Korea[11)15)16)22)24] and in the U.S.[25] Vegetarians were especially low in their intakes reaching only 1,300 kcal per day or 65% of RDA. This level of intake is lower than previous reports on adult females on normal diets and monks on vegetarian diet[23]. Vegetarians were also low in their protein intakes but their RF intake was similar to omnivores. Both groups consumed about 1.4mg of RF per day exceeding 1.2mg of RDA. This is higher level than the report by Yun et al[23]. of 1 mg per day in adult females both on normal and vegetarian diets but lower than 1.6-2.2 mg RF per day reported by Lee and Moon[16]. When RF intake was calculated per 1,000 kcal vegetarians were consuming higher level than omnivores primarily due to their lower energy intakes. But both groups were obtaining much higher level than Korean RDA level of 0.6 mg per 1,000 kcal. Major food sources of RF in vegetarians were fruits and vegetables such as strawberries and cucumbers which have little calorie value. Milk consumption in the students were generally low. Only five students had milk consumption of more than 1 cup per day. One of the five students had EGRAC value above 1.2.

EGRAC values of the students in the present study indicates that they are generally deficient in RF. Biochemical lesions were more severe in vegetarians in terms of both mean EGRAC value and the percentage of students with EGRAC values above 1.2. (See Table 1 and Figure 1). The prevalence of RF deficiency, 55.0% in omnivores and 82 % in vegetarians, is higher than that in other studies conducted with the same method. In adult females of 17 to 35 years of age in the U.S.A., Newman et al[26]. reported that the prevalence of RF deficiency was 11% and Garry et al[9]. found about the same result. In adolescent population, the prevalence of RF deficiency varied from 4% in white males and 37.9% in black females[4]. Other studies on adolescents in low socioeconomic status[10] and in Nigeria[7] found 23% and 28% of the subjects respectively in RF deficiency. For healthy adult females in Korea, the prevalence of RF deficiency in the present study is either higher[13] or lower[18] than previous reports. These reports contain neither dietary intake nor urinary data, and it is not possible to speculate further on the difference. Pregnant women seem to have even higher prevalence of RF deficiency. Kim[18] found that 92% of the pregnant subjects had EGRAC values above 1.2 and their mean EGRAC value was 1.638. A study on the pregnant and lactating women in Gambia whose dietary intake of RF was estimated to be 0.5mg per day[27], showed the mean EGRAC values of 1.75±0.24 and 1.82 ±0.28 respectively. Only 2.5% of the subjects had EGRAC values below 1.3.

For adult healthy normal females, present study population had remarkably high prevalence of RF deficiency. The prevalence was even higher in vegetarians even though they had similar daily RF and energy intakes and higher RF intakes per 1,000 kcal compared to omnivores. The reason for this is not clear at the present time.

When the subjects were divided into two groups according to their EGRAC values, students with EGRAC values above 1.2 had lower intakes of nutrients including RF even though the differences were not significant (See Table 2). As in previous reports[4)7)27] after daily supplementation of 5 mg of RF for one week, students with elevated EGRAC values returned to normal (See Table 3). Therefore, even though their RF intake was normal, they had biochemical lesions initially which were corrected by the RF supplementation.

As shown in Table 4, EGRAC values of the subjects were not significantly correlated with any of the dietary factors examined. EGRAC values were negatively correlated with all the nutrients energy, protein, and RF–so students with higher intakes of these nutrients tend to be in better RF nutriture. The lack of association between dietary intake of RF and RF nutriture is not easy to interpret but several reasons are possible. First, it could reflect the high individual variability in RF requirements as in other nutrients[28]. Elåboration on this subjects seems to be beyond the scope of this paper. Secondly, RF intake was calculated based on the food intake record and food composition table[29] which does not account cooking loss. It is not exactly known how much RF is lost during cooking and handling but since it is a water-soluble vitamin sensitive to light, a considerable amount can be lost during the storage, washing and cooking. The estimated loss during cooking process is reported to be 25% by Lee[15] or 10% by Chun et al[30]. If we follow the former, the average RF intake among the students in our study become 1.07mg per day, and it is 1.27mg per day if the latter is correct. These levels are either below or slightly higher than present RDA level of 1.2mg per day. Thirdly, RF intake could be influenced by the season. Our study was conducted in early summer and the students had high consumption of strawberries and cucumbers which contain 0.53mg and 0.50mg of RF per 100 grams respectively. This may have resulted in higher intake of RF than their usual intake level. Evidences supporting this are two-folds: (1) Omnivores were studied about one month later than the vegetarians in our study. Omnivores were thus surveyed just after the strawberry season in Korea and vegetarians were surveyed at the peak of the season. As pointed out earlier, vegetarians had high consumption of strawberries and this was reflected in their lower intake of energy and protein but similar intake of RF compared to omnivores. (2) The survey by Yun[23] which was conducted in late fall on subjects similar to the present study showed that their intakes of energy and protein were higher than our results but RF intake was lower. Therefore, our study may overestimate RF intakes of the students, especially in vegetarians. Lastly, the accuracy of dietary survey in assessing actual nutrient intake of an individual is always open to question. Unlike in metabolic studies where subjects are restricted in their nutrient intakes, physical activity, and other variables affecting one's nutritional status, precise estimation of usual nutrient intake level of individuals in free-living conditions poses a great diffeculty[31]. Thus the methods used in dietary surveys have been tested in various studies to find out the best way to correctly measure how much nutrient one consumes from diet[32)33]. Even though the estimation of a particular day of the survey was correct, intraindividual variation is reported to be greater than interindividual variation[32]. Therefore, how accurately the individual intake from our survey reflects the usual intake level of each subject remains unknown. According to Mullen et al[34]. different food items have different tendancy in terms of the accuracy the intake is estimated. Among the 159 food items reported, overall correlation between the record and actual intake was significant but there was a tendancy to overestimate their intakes among the subjects. The overall rate of overestimation was 45% while that of underestimation was 13%. The remainder was accurate estimation. Fruits and vegetables were more frequently overestimated than underestimated. Fruits were overestimated 54 % and underestimated only in 9% of the time while in vegetables the percentages were 42 and 14 respectively. On the other hand, flesh foods and grains are estimated more accurately and less frequently overestimated than fruits and vegetables. In terms of nutrients, such trends would lead to more accurate estimation of nutrients from grains and flesh foods, notably energy and protein and greater overestimation of nutrients which mainly come from fruits and vegetables. If we assume that the same trend occurred in our survey, RF, which comes from fruits and vegetables rather than grains and flesh foods could be overestimated to a greater extent compared to energy and protein intakes. In short, errors in estimation of RF intake could have occurred in several ways which all tend to lead to an overestimation.

In the analysis of dietary survcy data, nutrient contents of each food item were obtained from food Composition Table published by the Rural Nutrition Institute, Korea[29]. This table is found to be substantially high in RF content of some foods, especially in cucumbers and strawberries. If values which are more commonly found in other food composition tables[37], 0.07mg/100g for strawberries and 0.04mg/100g for cucumbers, results obtained differ in several important points. The everage daily RF intake levels in all subjects was 1.26 ± 0.04mg and that in omnivores and vegetarians were 1.30 ± 0.05mg and 1.18 ± 0.05mg respectively. The difference between the two groups were significant ($p < 0.05$), but the intake levels were adequate to meet Korean RDA of 1.2mg in both groups. Correlation coefficient between daily RF intake and EGRAC values of the subjects was -0.02747 which was significant at the level of $p < 0.05$ Therefore the subjects with higher dietary RF intake had lower EGRAC values -- a better RF nutritional status.

RF nutriture as judged by EGRAC on subjects with adequate level of dietary RF intake has been reported to be biochemically deficient in several reports[5)-7)27)35)]. This has been used as evidence for raising present RDA levels. The result of our study confirms this view. Since high percentage of our subjects were in marginal biochemical deficiency and recovered by RF supplementation they should increase their dietary RF intake levels to maintain biochemical normality. This is more true for vegetarians.

RF requirement has been considered to be related to energy or protein intakes[28)35)36)] even though there exists little convincing evidence to support such views. In the present study, vegetarians who consumed less energy and proteins than omnivores seem to have higher RF requirements since their biochemical lesions were more severe with similar RF intakes. More investigations on this subject is required for correct interpretation of the result.

In this study, biochemical deficiency was judged by EGRAC 1.2 which is the generally accepted criteria based on the studies done in western countries. Considering the differences in the diet and life style of these subjects and those in the present study, more caution may have to be given in interpreting the results. More studies are necessary in terms of dietary intake and nutritional status of riboflavin in Koreans. These studies will be valuable to reexamine Korean RDA level of riboflavin.

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