

Nutritional Status of Thiamin in Elementary School Children Living in Rural Areas of Chungbuk

Eun-Hee Jung,[†] Kyung-Hee Han,¹⁾ Mee-Sook Choi²⁾

School of General Education, Department of Food and Nutrition,¹⁾ Seowon University, Cheongju, Korea

Department of Diet and Health Management,²⁾ Chung Cheong College, Cheongju, Korea

ABSTRACT

The present study was performed to assess nutritional status of thiamin in 104 elementary school children, living in rural areas of Chungbuk. Dietary intake was obtained by 24 hour recall method and blood was collected to analyze the transketolase activity in erythrocytes. Average dietary intake of thiamin was found to be adequate (1.15mg, 109.2% of RDA), even though dietary intake of energy was not more than 1,719kcal, 81.5% of RDA. Transketolase activity in erythrocytes was distributed in the range of 0.294–0.744mU/mgHb and the mean value was 0.540mU/mgHb. The mean value of TPP effect was 7.9% and the range was 0–77.4%. It appeared that 7.7% of children were deficient in thiamin, severely or marginally. There were no significant correlations between transketolase activity and dietary thiamin intake, and between TPP effect and dietary thiamin intake. Mean DVS (Dietary variety score) of the children was 14.2 ± 3.2 and DVS was apparently correlated with thiamin intake. (*J Community Nutrition* 5(3) : 127~131, 2003)

KEY WORDS : dietary thiamin · transketolase · TPP effect · elementary school children.

Introduction

Although a great deal of attention is given to macronutrient and energy intake in the diet, elements essential to dietary metabolic balance include important micronutrients. Thiamin is an essential cofactor for key enzymes involved in aerobic and anaerobic metabolism, and has been considered as one of the most susceptible vitamins to be deficient marginally or severely. Beriberi was the first disease to be associated with thiamin deficiency, and Wernicke-Korsakoff syndrome was shown to respond to thiamin treatment a few years later (Jung et al 1993). According to a Korean National Health and Nutrition Survey report (Shin 2000), daily dietary intake of thiamin in Korea has been known to be enough, showing 126.6% of RDA. However, studies about specific groups have reported a slight difference, showing the distribution from 50 to 131% of RDA (Cho 2000 ; Jung,

Han 2000 ; Lee et al. 2000 ; Ro 2000 ; Yoon et al. 2000). There are many enzymes that are stimulated by *in vitro* addition of their coenzymes, for example, glutathione reductase and aspartate aminotransferase are activated by FAD and pyridoxal phosphate, respectively. And these stimulatory effects by the vitamins have been used as reliable indices of the nutritional status of these vitamins. Thiamin pyrophosphate (TPP) is the active form of thiamin, and it serves as a cofactor for several enzymes involved in carbohydrate catabolism. Of all the methods for thiamin measurement, transketolase assay in erythrocytes has been known as the most practical method to measure thiamin status and TPP effect is expressed as a percent stimulation of transketolase activity with *in vitro* addition of thiamin pyrophosphate. Usually, above 20 percent of TPP effect has been considered to reflect the state of thiamin deficiency. And from 15 to 20 percent of TPP effect has been considered to reflect marginal deficiency. Indeed, low transketolase activity in red blood cells and an unusually large stimulation by added TPP are used to diagnose thiamin deficiency. Although there were just a few studies by biochemical enzymatic assay, the results from biochemical assay suggested a high incidence of marginal to deficient

[†] Corresponding author : Eun-Hee Jung, School of General Education, Seowon University, 231 Mochung-dong, Cheongju 361-742, Korea

Tel : (043) 299-8303, Fax : (043) 299-8303

E-mail : ehjung@seowon.ac.kr

state, and were not positive as in the survey of dietary intake (Chang, Kim 1999, Tchai 1977). Over the years, the study on the thiamin has been rarely done, especially in rural areas which might be more vulnerable. Generally, the nutritional status of children was affected by residential district as well as gender and economic state of the family. The socio-economic difference between urban and rural areas has been increased by rapid and unbalanced economic development of Korea for years. This kind of situation might bring on less concern about the diet in rural areas, and especially nutritional care for children is liable to be neglected (Ro 2000). Lee, Jung (1987) reported that the nutritional status of children in rural areas was not positive and so does the physical condition as compared as that in urban areas.

In this report, we describe the dietary thiamin intake by 24 hour recall method and biochemical status of thiamin by enzymatic assay in elementary school children living in rural areas of Chungbuk.

Subjects and Methods

Subjects for this study were 104 children of the 5th and 6th grade in elementary school from rural areas of Chungbuk. Height and weight were measured and dietary intake data were obtained by 1 day 24 hour recall method. Biochemical enzymatic assay was used to assess the thiamin status. The blood was collected using the EDTA treated tube (Vacutainer, Becton Dickinson and Company, NJ). The erythrocytes were separated by centrifugation at 2,000 rpm for 10min, washed three times with saline solution by centrifugation at the same condition as above and kept at -70°C until use. To determine the transketolase activity, the hemolysates were prepared with addition of the same volume of the distilled water to the packed red blood cells. The transketolase activity in hemolysates was determined by the formation rate of D-sedoheptulose 7-phosphate using ribose 5-phosphate as a substrate (Jung et al. 1991). One hundred microliters of the hemolysates and $80\ \mu\text{l}$ of 20mM Tris buffer (pH7.9) were incubated with $20\ \mu\text{l}$ of 1mM TPP or distilled water at 37°C for 30min followed by heating at 55°C for 5min. Then $40\ \mu\text{l}$ of 36mM ribose 5-phosphate was added and incubated at 37°C for 30min. The reaction was stopped by addition of $600\ \mu\text{l}$ of 7.5% trichloroacetic acid. The following steps were the same as the method of Takeuchi et al (1984). Hemoglobin concentration in hemoly-

sates was determined by the cyan-methemoglobin method with a hemoglobin test kit (Hemo-S reagent, Yeongdong Pharmaceutical Co.).

Thiamin pyrophosphate, sedoheptulose 7-phosphate and ribose 5-phosphate for transketolase analysis were purchased from Sigma, and all other chemicals were reagent grade materials from commercial sources.

The data analysis was performed using S-plus 2000 (Mathsoft) program. We provided results about mean and standard deviation, frequency and percentages of distribution. Correlation analysis was made by computing Pearson's correlation coefficients to assess the relation of dietary thiamin intake to transketolase activity, TPP effect and DVS.

Results and Discussions

Anthropometric characteristics of the subjects are presented in Table 1. The mean value of height and weight were 151.8cm and 43.6kg respectively, which are higher than Korean standard value (RDA for Korean 2000). The mean value of BMI was 18.8, which was in normal range (18.5–19.1), however the percentage of overweight and obesity were 25% and 4.8%, respectively. Especially, in case of female students, BMI was higher, and the percentage of overweight and obesity was significantly higher than that of male students (Table 2).

Dietary intake of energy and thiamin based on the 24 hour recall method are presented in Table 3. The RDAs of energy and thiamin for Korean 10-12 year-old were 2,200kcal, 1.1 mg for male and 2,000kcal, 1.0mg for female, respectively. Energy intake in this study was found to be very low (81.5%

Table 1. Anthropometric characteristics of the subjects

Variables	Male	Female	Total	Standard value
Height(cm)	150.6 \pm 8.6 ¹⁾	153.2 \pm 5.2	151.8 \pm 7.4	144
Weight(kg)	40.9 \pm 3.1	46.9 \pm 11.6	43.6 \pm 10.2	38
BMI(kg/m ²)	18.0 \pm 2.8	19.9 \pm 4.4	18.8 \pm 3.7	18.5

¹⁾ Mean \pm SE

BMI: Body Mass Index

Table 2. Distribution of BMI of the subjects

	N(%)		
	male (n = 57)	Female (n = 47)	Total (n = 104)
≤ 15	5(8.8)	3(6.4)	8(7.7)
15 < \leq 20	39(68.4)	26(55.3)	65(62.5)
20 < \leq 25	11(19.3)	15(31.9)	26(25.0)
25 < \leq 30	2(3.5)	1(2.1)	3(2.9)
30 < \leq 60	0(0.0)	2(4.3)	2(1.9)

of RDA), which is similar with the result of previous studies (Lee, Chang 1999 ; Ro 1997). However, considering the current nutrient requirements, most of the children have adequate dietary intake of thiamin (109.2%).

Transketolase activity and TPP effect are shown in Table 4 and the distribution of TPP effect are shown in Table 5. The transketolase activities were distributed in the range of 0.294–0.744mU/mgHb, and the mean value was 0.540mU/mgHb. In Korea, there are a few available data on transketolase activity to compare with. We determined transketolase activity from young college women in Japan and showed the range of 0.4–0.8mU/mgHb (Takeuchi et al. 1988), which is a little higher than in this study. Chang and Kim (1999) were also determined thiamin status in rural areas by measurement of transketolase in erythrocytes, however, unfortunately, they provided only TPP effect and not transketolase activity itself. Recently, we determined the transketolase activity in Korean elderly women and showed the range of 0.227–0.589mU/mgHb, which is slightly lower than that of this result. It was also observed that, although

the thiamin intake for each 1,000kcal seemed adequate in elderly women, thiamin status judged by transketolase activity in erythrocytes seemed very poor, showing up to 95% of the subjects had marginal or severe deficiency (Jung, Han 2000). In other words, recent studies showed positive results of dietary thiamin intake, nevertheless still thiamin remained as one of the most susceptible vitamins to be deficient marginally or severely. In this present study, thiamin status in most of the subjects seemed to be adequate and only 8 of 104 students were found to be severely or marginally deficient in thiamin status, showing 6 students to be above 20% and 2 students to be from 15 to 20% of TPP effect (Table 5). The mean value of TPP effect was 7.92% and the range was broad, from 0 to 77.4%. Tchai (1977) showed 14–18% of TPP effect in young college students, and Chang, Kim (1999) showed 30.1% of TPP effect in healthy elderly. Also, our previous study showed that mean value of TPP effect was 24.0% and the range was broad, from 9.3 to 83.9 in elderly women (Jung, Han 2000). In this result, overall nutritional status of thiamin of the children was found to be comparably positive and severe thiamin deficiency remained quite low among the children from both dietary survey and biochemical assay. Although the thiamin status of children was found to be relatively positive in this result, 7.7% of the children still showed deficiency in thiamin and needs to be take care of.

Theoretically, transketolase activity is supposed to be increased when dietary thiamin intake increased. However, the result of biochemical enzymatic assay does not seem to correlate with the dietary thiamin intake (Table 6). This inconsistency can be explained partly by inaccurate information from the survey for the children. Feldman (1993) indicated the inadequacy of the current methodology of dietary assesment. It is also suggested that dietary intake of nutrients, which has been estimated mostly by food record or 24 hour recall method for only 1 day, may not be able to

Table 3. Dietary intake and percentage of RDA for energy and thiamin

	Male	Female	Total
Calorie (kcal)	1769 ± 490 ¹⁾	1658 ± 430	1719 ± 465
% of RDA	80.4% ²⁾	82.9%	81.5%
Thiamin (mg)	1.16 ± 0.38	1.14 ± 0.34	1.15 ± 0.36
% of RDA	105.1%	114.2%	109.2%

1) Mean ± SE

2) Percentage of Korean RDA (2000)

Table 4. Transketolase activity and TPP effect of elementary school children

	Male	Female	Total
Transketolase activity (mU/mgHb)	0.54 ± 0.09 ¹⁾	0.54 ± 0.07	0.54 ± 0.08
TPP effect ²⁾	7.99 ± 8.13	7.85 ± 10.98	7.92 ± 9.48

1) Mean ± SE

2) A percent stimulation of transketolase activity with *in vitro* addition of thiamin pyrophosphate

Table 5. Distribution of TPP effect of the subjects

TPP effect ¹⁾	N = 104 (100%)
≤ 10	89 (85.6%)
10 < ≤ 20	9 (8.7%)
20 < ≤ 30	4 (3.8%)
50 < ≤ 60	1 (1.0%)
70 < ≤ 80	1 (1.0%)

1) A percent stimulation of transketolase activity with *in vitro* addition of thiamin pyrophosphate

Table 6. Correlation coefficient among four variables

Variables	Transketolase activity	Tpp effect	Thiamin intake
TPP effect ¹⁾	-0.4370		
Thiamin intake	-0.0912	-0.1114	
DVS ²⁾	-0.1271	-0.1405	0.4905

1) A percent stimulation of transketolase activity with *in vitro* addition of thiamin pyrophosphate

2) Dietary variety score

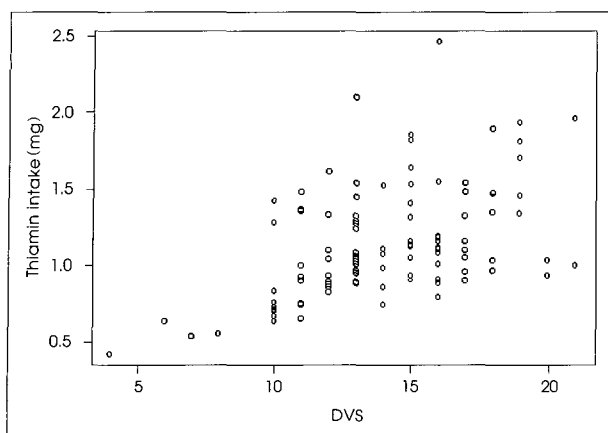


Fig. 1. Distribution of dietary thiamin intake and DVS.

Table 7. Distribution of DVS in subjects

DVS	N = 104 (100%)
< 10	4 (3.8%)
10 < ≤ 15	49 (47.1%)
15 < ≤ 20	47 (45.2%)
20 ≤	4 (3.8%)

1) Dietary variety score

reflect the chronic nutritional status (Oh, Hong 1998).

The preferred way of preventing micronutrient deficiencies would be by securing dietary diversification. Table 7 shows the distribution of DVS. Mean DVS of the children was quite low (14.2 ± 3.2 ; boys 13.8 ± 3.1 , girls 14.6 ± 3.30), and thiamin intake was apparently correlated with DVS (Table 6, Fig 1). It was also suggested that experiencing and eating diverse foods at this age helps to promote desirable eating behaviors (Birch 1987). More attention needs to be given to the diversification of food in school meals and nutrition education programs.

Conclusions

To evaluate the dietary and nutritional status of thiamin in elementary school children living in rural areas, dietary intake was obtained by 24 hour recall method and nutritional status of thiamin was determined by measurement of transketolase activity in erythrocytes. The mean values of height and weight were 151.8cm and 43.6kg. The mean value of BMI was 18.8, and the percentage of overweight and obesity were 25% and 4.8%, respectively. According to the current nutrient requirements, average dietary thiamin intake of the children was found to be adequate (1.15mg, 109.2% of

RDA), even though dietary intake of energy was not more than 1,719kcal, 81.5% of RDA. Transketolase activity in erythrocytes was distributed in the range of 0.294–0.744 mU/mgHb and the mean value was 0.540mU/mgHb. The mean value of TPP effect was 7.9% and the range was 0–77.4%. It appeared that 7.7% of children were deficient in thiamin, severely or marginally. There were no significant correlations between transketolase activity and dietary thiamin intake, but thiamin intake was apparently correlated with DVS.

In this result, overall nutritional status of thiamin was comparably positive and severe thiamin deficiency remained quite low among the children from both dietary survey and biochemical assay. Although the thiamin status of children was found to be relatively positive in this result, some of the children still showed deficient in thiamin and needs to be take care of.

References

- Birch I (1987) : The role of experience in children's food acceptance pattern. *J Am Diet Assoc* 87 (suppl 9) : 536
- Chang NS, Kim EJ (1999) : Thiamin and riboflavin nutritional status of subjects with alcohol dependency in rural Area. *Korean J Nutr* 32 (2) : 175-181
- Cho SS (2000) : Implementation and evaluation of a nutrition education program to improve the nutritional and physiological status of female gymnasts. *Korean J Comm Nutr* 5 (1) : 50-62
- Feldman EB (1993) : Aspects of the interrelations of nutrition and aging. *Am J Clin Nutr* 58 : 1-3
- Jung EH, Han KH (2000) : Dietary thiamin intake and TPP effect of elderly women. *J Commu Nutr* 2 (2) : 141-145
- Jung EH, Sheu KFR, Blass JP (1993) : An enzymatic and immunochemical analysis of transketolase in fibroblasts from Wernicke-Korsakoff syndrome. *J Neurol Sci* 114 : 123-127
- Jung EH, Takeuchi T, Nishino K, Itokawa Y (1991) : Effect of alcohol administration on transketolase in the brain and the liver of rats. *Am J Clin Nutr* 53 : 100-105
- Lee SS, Jung HS (1987) : A study on lunch nutritional status of elementary school students in Kyungnam area. *J Kor Home Economis* 25 (3) : 49-61
- Lee SW, Sung CJ, Kim AJ, Kim MH (2000) : A study on nutritional attitude, food behavior and nutritional status according to nutritional knowledge of Korean middle school students. *Korean J Comm Nutr* 5 (3) : 419-431
- Lee YJ, Chang KJ (1999) : A comparative study of obese children and normal children on dietary intake and environmental factors at an elementary school in Incheon. *Korean J Comm Nutr* 4 (4) : 504-511
- Oh SY, Hong MH (1998) : Repeatability of a semi-quantitative food frequency questionnaire of the Korean elderly. *Korean J Nutr*

- 31 (7) : 1183-1191
- Recommended dietary allowances for Koreans. 7th revision, The Korean Nutrition Society (2000)
- Ro HK (1997) : Nutritional status of female students in the sixth grade attending a rural primary School. *Korean J Comm Nutr* 2 (3) : 275-280
- Ro HK (2000) : Comparisons of nutrient intakes, dietary behavior and perception about body image between adolescent boys and girls in rural area. *Korean J Comm Nutr* 5 (2S) : 280-288
- Shin AJ (2000) : '98 National Health and Nutrition Survey. *Korean J Commu Nutr* 5 (3) : 549-553
- Takeuchi T, Jung EH, Nishino K, Itokawa Y (1988) : Western blotting assay of transketolase concentration in human hemolysates. *Anal Biochem* 168 : 470-475
- Takeuchi T, Nishino K, Itokawa Y (1984) : Improved determination of transketolase activity in erythrocytes. *Clin Chem* 30 : 658-661
- Tchai BS (1977) : Biochemical assesment of vitamin B1, B2, and B6 nutriture by coenzyme activation on erythrocytes enzymes. *Korean J Nutr* 22 (6) : 507-515
- Yoon JS, Lee JH, Park PS (2000) : Zinc status and taste acuity of old and young women. *Korean J Comm Nutr* 5 (3) : 484-492