

Original Article

Evaluation of folate status by serum and erythrocyte folate levels and dietary folate intake in Taiwanese schoolchildren

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The folate status and dietary folate intake of Taiwanese schoolchildren was investigated by analysis of both serum and red blood cell (RBC) folate levels and dietary folate intake in 1105 boys and 958 girls aged 6-13 years sampled from the Nutrition and Health Survey in Taiwan Elementary School Children 2001-2002 (NAHSIT Children 2001-2002). Mean serum folate levels were 18.3±8.8 nmol/L (8.1±3.9 ng/mL) in boys and 20.3±9.7 nmol/L (9.0±4.3 ng/mL) in girls. Mean RBC folate levels were 700±320 nmol/L (308±141 ng/mL) in boys and 751±347 nmol/L (331±153 ng/mL) in girls. The prevalence of serum folate deficiency was 1.4% in boys and girls, and the prevalence of marginal serum folate deficiency (7-14 nmol/L) was 31.1% in boys and 25.8% in girls. In addition, 8.5% of boys and 7.4% girls had RBC folate deficiency (RBC folate < 318 nmol/L), and 17% of children had marginal RBC folate deficiency (RBC folate of 318-454 nmol/L). Our results suggesting that Taiwanese schoolchildren have poor folate status especially during periods of rapid growth and development such as the transition from childhood to early adolescence (boys at age 12-12.9, girls at age 11-12.9). The average estimated folate intakes were 269±9 µg/d in boys and 259±9 µg/d in girls, and 42% of Taiwanese schoolchildren had a dietary folate intake below 2/3 of the RDA, indicating a poor dietary folate intake in this population. This study shows that the folate status of Taiwanese schoolchildren is currently inadequate and strategies are needed for improvement.

Key Words: folate intake, serum folate, RBC folate, schoolchildren, NAHSIT 2000-2001

INTRODUCTION

Recent studies have shown that elevated plasma homocysteine (Hcy) is associated with cardiovascular disease and venous thrombosis in children.¹⁻³ Much previous research has focused on adults and only a few studies have found a strong inverse association between plasma Hcy levels and folate levels in children.⁴⁻⁶ Adequate folate nutrition has been emphasized in recent years because of the association of low folate status with neural tube defects,⁷ brain development, and emergent cognitive functions in children.^{8,9} Such findings have led to increased attention being placed on folate status in children. However, data on folate status in children are sparse.

Folate status may be evaluated from serum/plasma, RBC levels and dietary folate intake.¹⁰ The serum/plasma folate reflects recent folate status, whereas RBC folate levels are considered to be an indicator of long term status.¹¹ Therefore, in addition to the evaluation of folate status in schoolchildren by serum folate levels, RBC folate level is an important indicator for those children entering adolescence. Serum folate may be lower due to rapid tissue growth and development, but low RBC folate levels would imply poor body stores of folate which may affect adolescent development. Folic acid fortification has markedly improved

serum folate, and RBC folate levels in the United States and Canada.^{12,13} Recommended dietary intakes for folate differ among countries and range from 300 to 400 µg/day.^{14,15} In Taiwan, the recommended Dietary Allowance (RDA) for folate is 200 µg/d for children aged 6-6.9 yrs, 250 µg/d for 7-9.9 yrs, and 300 µg/d for 10-12.9 yrs.¹⁶ A previous survey, the Nutrition and Health Survey in Taiwan (NAHSIT 1993~1996), revealed that 9-13% of Taiwanese children aged 7-12 yrs had plasma folate insufficiency, or RBC folate insufficiency.¹⁷ The NAHSIT 1993~1996, however included only 400 children, and the database on folate content for most vegetables and food produced in Taiwan was not fully available at the time.

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In this NAHSIT Children 2001-2002 survey, we evaluated dietary folate intakes using the folate composition databank for a Chinese-style diet as described previously.^{18,19} In addition, we also measured serum and RBC folate to more comprehensively evaluate folate status in the Taiwanese schoolchild population.

MATERIALS AND METHODS

Subjects

The subjects in this study were schoolchildren sampled from the Taiwanese population using a multistage, stratified sampling method, as part of the NAHSIT Children 2001-2002. Detailed description of sampling design can be found in Tu *et al*'s report.²⁰ The sample included 2063 subjects, comprising 1105 boys and 958 girls aged 6 to 13 yrs.

Measurement of folate

Serum and RBC folate were measured by a combined system of competitive immunoassay and chemiluminescence (IMMULITE 2000 analyzer, Diagnostic Products Corporation, LA, CA). This procedure involved the use of monoclonal antibodies, paramagnetic particles, and a chemiluminescence substrate. The light emitted was inversely proportional to the concentration of folic acid. A series of quality control tests were performed to evaluate the precision of this assay. These tests confirmed both the between- and within-run consistency of this method. The Coefficients of Variation (CV) for serum folate, and RBC folate were 8.5 %, and 6.8%, respectively. Folate deficiency was defined as a serum folate < 7 nmol/L (3.0 ng/mL) or RBC folate < 318 nmol/L (140 ng/mL). Marginal folate deficiency was defined as a serum folate between 7-14 nmol/L (3.0-6.0 ng/mL) or RBC folate between 318-454 nmol/L (140-200 ng/mL). Folate insuffi-

ciency was defined as a serum folate ≤ 14 nmol/L (6 ng/ml) or RBC folate ≤ 454 nmol/L (200 ng/ml).²¹⁻²³

Dietary assessment

Dietary folate intake was assessed using data from 24-hour dietary recalls and calculated the dietary folate intake using the folate composition databank.¹⁸ This was prepared by integrating the information on food folate contents from 1) USDA Nutrient database for standard reference,²⁴ 2) Bowes & Church's food values of portions commonly used²⁵ 3) folate contents for vegetables commonly used in Taiwan.²⁶ The RDA in Taiwan for folate is 200 µg/d for children aged 6-6.9 yrs, 250 µg/d for 7-9.9 yrs, and 300 µg/d for 10-12.9 yrs.¹⁶ Subjects with daily folate intake below 2/3 of the RDA were considered to have inadequate folate intake.

Statistical analysis

Statistical analysis was carried out with the SAS program (SAS/STAT Version 8.2, SAS Institute, Cary, NC). As the NAHSIT Children 2001-2002 was conducted using a stratified, multistage probability design, sample weighting was used to account for the complex survey design in the variance estimates, using SUDAAN, SAS-callable version 8.2. The data were analyzed by gender, and age was divided into one year intervals (6-6.9, 7-7.9, 8-8.9, 9-9.9, 10-10.9, 11-11.9, and 12-12.9 yrs). Trends across tertiles were evaluated with linear regression. Student's t test was used for the analysis of differences in continuous variables, and the chi-squared test was used for analysis of differences in categorical variables. Differences were considered significant if $p < 0.05$.

RESULTS

Data presented in Table 1 show that serum folate levels

Table 1. Serum folate levels and folate status of Taiwanese schoolchildren by age¹

Age group (yrs)	N	Serum folate (nmol/L)	Serum folate status		
			Deficiency ² (%)	Marginal deficiency ² (%)	Insufficiency ² (%)
Males					
6-6.9	87	21.5±2.1	0	23.2	23.2
7-7.9	202	19.1±0.7*	0.5	26.6	27.1*
8-8.9	171	18.9±1.0*	2.2	30.9	33.1*
9-9.9	180	17.7±0.5*	1.2	31.9	33.1
10-10.9	185	18.7±0.8	0.8	31.7	32.5
11-11.9	202	17.8±1.0	1.8	33.3	35.1
12-12.9	78	14.7±0.6	3.2	40.8	44.0
<i>p</i> for trend		<0.001			0.003
Total	1105	18.3±0.4*	1.4	31.1	32.5*
Females					
6-6.9	75	22.9±1.5	0	16.6	16.6
7-7.9	150	24.7±1.6	1.1	12.1	13.2
8-8.9	154	23.3±1.1	0	12.8	12.8
9-9.9	154	21.1±1.1	3.1	26.2	29.3
10-10.9	175	19.0±0.8	1.0	30.3	31.3
11-11.9	164	16.1±0.8	2.3	42.5	44.8
12-12.9	86	15.7±0.8	1.5	42.3	43.8
<i>p</i> for trend		<0.001			<0.001
Total	958	20.3±0.6	1.4	25.8	27.2

¹ All values are shown as mean ± SE or percentage of participants. ² Serum folate levels < 7 nmol/L (3.0 ng/mL) indicate deficiency; between 7-14 nmol/L (3.0-6.0 ng/mL) indicate marginal deficiency; and ≤ 14 nmol/L (7.0 ng/mL) indicate insufficiency. *Significantly different from the female values ($p < 0.0001$).

Table 2. RBC folate levels and folate status in Taiwanese schoolchildren by age¹

Age group (yrs)	N	RBC folate (nmol/L)	RBC folate status		
			Deficiency ² (%)	Marginal deficiency ² (%)	Insufficiency ² (%)
Males					
6~6.9	87	733±40*	7.6	13.3	20.9
7~7.9	202	748±27*	7.9	15.1	22.9
8~8.9	171	727±29*	5.4	21.0	26.4*
9~9.9	180	705±21*	9.7	14.8	24.4
10~10.9	185	697±24	9.1	14.3	23.5
11~11.9	202	657±22	8.2	18.8	27.0
12~12.9	78	614±44	13.4	21.1	34.5
<i>p</i> for trend		0.002			0.027
Total	1105	700±13	8.5	16.9	25.4
Females					
6~6.9	75	889±63	1.3	11.5	12.8
7~7.9	150	850±35	2.1	8.5	10.6
8~8.9	154	833±34	3.4	9.5	12.8
9~9.9	154	796±40	5.5	20.5	25.9
10~10.9	175	710±30	9.2	17.1	26.3
11~11.9	164	580±25*	15.0	30.5	45.5*
12~12.9	86	612±45	15.6	20.3	35.9
<i>p</i> for trend		<0.001			<0.001
Total	958	751±19	7.4	17.1	24.5

¹ All values are shown as mean ± SE or percentage of participants. ² RBC folate levels < 318 nmol/L (140 ng/mL) indicate deficiency; between 318-454 nmol/L (140-200 ng/mL) indicate marginal deficiency; and ≤ 454 nmol/L (200 ng/mL) indicate insufficiency. *Significantly different between sexes (*p*<0.0001).

Table 3. Dietary folate intake in Taiwanese schoolchildren by age¹

Age group (yrs)	n	Folate intake ¹ (µg/d)	Inadequate intake ² (%)
Males			
6~6.9	87	244±20	31.6
7~7.9	202	261±22	37.0
8~8.9	171	244±19	40.6
9~9.9	180	276±18	38.0
10~10.9	185	282±18	41.2
11~11.9	202	264±14	44.1
12~12.9	78	322±31	35.9
<i>p</i> for trend		0.001	
Total	1105	269±9	41.3
Females			
6~6.9	75	234±23	35.0
7~7.9	150	210±15*	45.6
8~8.9	154	247±20	39.7
9~9.9	154	255±14	34.2
10~10.9	175	285±22	45.1
11~11.9	164	290±20	38.2
12~12.9	86	286±19	42.2
<i>p</i> for trend		<0.001	
Total	958	259±9	41.8

¹ All values are shown as mean ± SE or percentage of participants. ² Inadequate folate intake is indicated by a dietary folate intake <2/3 RDA in Taiwan. The RDA in Taiwan for folate is 200 µg/d for 6~6.9 yrs, 250 µg/d for 7~9.9 yrs, and 300 µg/d for 10~12.9 yrs. *Significantly different between sexes (*p*<0.01).

tended to decrease with age in both sexes (*p* for trend < 0.001). Boys had significantly lower serum folate levels than girls, especially between the ages of 7 to 9.9 yrs. The prevalence of serum folate deficiency (< 7 nmol/L) was

the same for boys and girls, but the prevalence of marginal serum folate deficiency (7-14 nmol/L) was 31.1% in boys and 25.8% in girls. Thus, the overall prevalence of serum folate insufficiency (≤ 14 nmol/L) was significantly higher in boys (32.5%) compared to girls (27.2%). The prevalence of serum folate insufficiency also increased with age in both sexes.

Data presented in Table 2 show that RBC folate levels also tended to decrease with age in both sexes (*p* for trend < 0.001). Boys still had significantly lower RBC folate levels between the ages of 6 to 9.9 yrs. However, at age 11-11.9 yrs girls had significantly lower RBC folate levels than boys. The prevalence of RBC folate deficiency (318 nmol/L, i.e. 140 ng/mL) and marginal RBC folate deficiency (RBC folate of 318-454 nmol/L, i.e.140-200 ng/mL) was similar for boys and girls. However, a higher prevalence of folate deficiency was observed when defined by RBC folate than by serum folate level. The overall prevalence of RBC folate insufficiency also increased with age in both sexes (*p* for trend < 0.05). The highest prevalence of serum or RBC folate insufficiency in girls occurred at ages 11-11.9 (44.8 % for serum folate, 45.5% for RBC folate), and 12-12.9 yrs (43.8% for serum folate, 35.9% for RBC folate), but in boys occurred at age 12-12.9 yrs only (44.0% for serum folate, 34.5% for RBC folate).

Estimated dietary folate intake is shown in Table 3. The folate intake levels in the schoolchild population increased with age due to increased dietary intake for growth. However, the average dietary intake did not meet RDA requirements in any age group, except in boys aged 12~12.9. There was no significant difference between boys and girls in dietary folate intake. The prevalence of low folate intake among Taiwanese schoolchildren was

Table 4. Effect of nutrient supplementation on dietary folate intake and folate status in Taiwanese schoolchildren¹

Variables	Regular nutrient supplementation					
	Males			Females		
	Yes (N=88)	No (N=1017)	<i>p</i> value	Yes (N=78)	No (N=880)	<i>p</i> value
Dietary folate intake ($\mu\text{g}/\text{d}$) ²	275 \pm 20	268 \pm 10	0.358	247 \pm 22	260 \pm 9	0.589
Serum folate (nmol/L) ²	23.6 \pm 2.0	17.7 \pm 0.4	0.005	28.8 \pm 3.0	19.5 \pm 0.5	0.001
RBC folate (nmol/L) ²	815 \pm 40	688 \pm 13	0.005	854 \pm 51	740 \pm 20	0.033
Serum folate insufficiency (%) ³	17.7	34.0	0.002	16.3	28.3	0.019
RBC folate insufficiency (%) ³	15.6	26.4	0.016	14.0	25.5	0.023

¹ All values are shown as mean \pm SE or percentage of participants. ² Adjusted for age. ³ Serum folate levels \leq 14 nmol/L (6.0 ng/ml) indicate serum folate insufficiency. RBC folate levels \leq 454 nmol/L (200 ng/mL) indicate RBC folate insufficiency.

Table 5. Serum and RBC folate levels in Taiwanese schoolchildren not taking nutrient supplements by tertile of dietary folate intake¹

Variables	Folate intake ($\mu\text{g}/\text{d}$)			
	<153	153~293	> 293	<i>p</i> for trend
Males				
N	333	342	342	
Serum folate (nmol/L) ²	17.0 \pm 0.5	17.9 \pm 0.6	18.8 \pm 0.8	0.010
RBC folate (nmol/L) ²	697 \pm 19	719 \pm 21	724 \pm 23	0.173
Females				
N	312	300	268	
Serum folate (nmol/L) ²	18.6 \pm 0.7	19.1 \pm 1.0	20.4 \pm 0.8	0.027
RBC folate (nmol/L) ²	720 \pm 27	731 \pm 31	744 \pm 20	0.634

¹ All subjects taking regular nutrient supplements were excluded. All values are shown as mean \pm SE. ² Adjusted for age.

assessed and it was found that about 41% of subjects had a daily folate intake below 2/3 of the RDA (2/3 of RDA in Taiwan for folate is 133 $\mu\text{g}/\text{d}$ for children aged 6~6.9 yrs, 167 $\mu\text{g}/\text{d}$ for 7~9.9 yrs, and 200 $\mu\text{g}/\text{d}$ for 10~12.9 yrs).

The effect of nutrient supplementation on dietary folate intake and biochemical indicators of folate status is shown in Table 4. About 9% of schoolchildren took nutrient supplements in this nation-wide survey. After adjustment for age, there was no difference between nutrient supplement users and non-supplement users in dietary folate intake for both sexes. However, the subjects who took nutrient supplements had significantly higher serum and RBC folate levels, and a lower prevalence of serum or RBC folate insufficiency than those who did not take nutrient supplements.

To investigate the effect of dietary folate intake on folate status, the association between dietary folate intake and serum and RBC folate levels among subjects not taking nutrient supplements was analyzed by tertile of dietary folate intake. The results are shown in Table 5. For both boys and girls, serum folate levels significantly increased with dietary folate intake (*p* for trend < 0.03), however, RBC folate levels did not significantly increase with dietary folate intake.

DISCUSSION

Early studies of folate nutritional status focused mostly on pregnant women and elderly people,²⁷ but children's folate status has become of increasing importance due to changes in dietary habits. In our previous study on the Taiwanese elderly, we showed that the elderly population consuming a Chinese-style diet and benefiting from the

abundance of a diverse variety of fruit and vegetables in Taiwan had no folate deficiency.¹⁹ However, as Western-style diets with increased amounts of fast-food become popular among the young generation in Taiwan, the folate status of children may be adversely affected. Some studies have indicated that folate deficiency can be found in schoolchildren.^{17,28-33} In our study, the average serum folate concentration in Taiwanese schoolchildren was 18.3 \pm 8.8 nmol/L (8.1 \pm 3.9 ng/mL) in boys and 20.3 \pm 9.7 nmol/L (9.0 \pm 4.3 ng/mL) in girls, which are lower than the average plasma folate levels in elderly people from the Elderly Nutrition and Health Survey in Taiwan (1999-2000) (Elderly NAHSIT).¹⁹ Our results showed that serum folate was significantly lower in boys than in girls, which is consistent with other studies.³¹ This suggests that folate status in the male population is an important issue, particularly as folate status is a strong determinant of total homocysteine in children.⁴

To compare our blood folate levels with those in other studies, we stratified age according to the age groups used in these studies and then reanalyzed our data. The mean serum folate level in Taiwanese schoolchildren was higher than figures in Dutch children (20.4 vs. 17.9 nmol/L, aged 6-10 yrs; 16.6 vs. 15.9 nmol/L, aged 11-13 yrs) and in the USA before folic acid fortification (20.3 vs. 19.3 nmol/L, aged 6-11 yrs, NHANES III),^{28,31} but lower than figures in Greek children (16.8 vs. 21.6 nmol/L for boys, 16.1 vs. 20.9 nmol/L for girls, aged 10-13 yrs),³⁰ in northeast Thailand (19.4 vs. 21.4 nmol/L, aged 6-13 yrs),³³ and in the USA after folic acid fortification (20.3 vs. 43.8 nmol/L, aged 6-11 yrs, NHANES 1999-2000).³¹ The mean RBC folate level in Taiwanese schoolchildren

was also lower than that found in northeast Thailand (755 vs. 842 nmol/L, aged 6-13 yrs),³³ and higher than those found in the USA before and after folic acid fortification (762 vs. 444 nmol/L, aged 6-11 yrs, NHANES III; 762 vs. 643 nmol/L, aged 6-11 yrs, NHANES 1999-2000).³¹

The prevalence of folate deficiency among children in different countries has varied substantially due to the use of different ranges of age. After reanalysis to take this into account, our data showed that the overall prevalence of RBC folate deficiency (< 318 nmol/L) in Taiwanese children is probably lower than that in Mexican children (6.4% for Taiwanese aged 6-11 yrs vs. 10% for Mexican aged 5-11 yrs).³² In our study, there was a 1.4% prevalence of serum folate deficiency and 7-9% prevalence of RBC folate deficiency in Taiwanese schoolchildren. The prevalence of marginal serum folate deficiency was also higher among schoolchildren than the elderly (26-31% vs. 12-18%).¹⁹ It should be mentioned that serum and RBC folate decreases with age without decrease of folate intake, suggesting folate requirement for adolescence may be higher. It is not known whether the same cut-offs are appropriate for children as little information is available to establish such cut-offs for this age group. The use of the adult cut-offs for folate status in schoolchildren may underestimate the extent of inadequate folate status in childhood. Our data indicated that schoolchildren in Taiwan have poorer folate status than the Taiwanese elderly. More attention should therefore be given to this important issue, especially as folate is associated with brain development and emergent cognitive function in children.^{8,9}

Our results showed that serum and RBC folate levels significantly decreased and the prevalence of insufficiency significantly increased with age in both sexes. This tendency is consistent with other surveys indicating an age-related reduction in serum and RBC folate during periods of rapid growth and development, such as the transition from childhood to early adolescence.^{31,34} Therefore, lower levels of serum and RBC folate in boys compared to girls was noted between ages 7-9.9 yrs, while girls had significantly lower RBC folate levels than boys at age 11-11.9 yrs. Importantly, the highest prevalence of serum (~44%) or RBC (36-46%) folate insufficiency and the highest dietary folate intake occurred in girls at age 11-12.9 yrs, and occurred in boys at age 12-12.9 yrs. These data suggests that folate status is particularly poor in those children entering adolescence, as a result of increased folate requirements due to rapid tissue growth and development. Therefore, adequate dietary folate intake is vitally important for such schoolchildren. Higher intakes of dark green vegetables, citrus fruits, gourds, pickled vegetables, seaweed are significantly correlated to higher RBC folate in our previous survey.¹⁷ Therefore, these food, as well as folate supplement, may be recommended to improve the folate status of schoolchildren.

The USA (NHANES III) study reported that average dietary folate intake was 270 µg/day in boys and 235 µg/day in girls aged 6-11 yrs, and 382 µg/day in boys and 220 µg/day in girls aged 12-15 yrs.³⁵ In our study, the estimated average dietary folate intake in a nation-wide survey of 2063 schoolchildren was 261 µg/d in boys and 246 µg/d in girls aged 6-11 yrs, and 322 µg/d in boys and 286 µg/d in girls aged 12-13 yrs using the folate compo-

sition databank described previously.¹⁸ The data suggest that Taiwanese male schoolchildren have lower folate intake, but that girls have higher folate intake compared to the folate intakes of US schoolchildren before folate fortification. In addition, 42% of the Taiwanese schoolchild population are at risk of inadequate dietary folate intake (dietary folate intake below 2/3 RDA values). This suggests that greater attention should be given to this important health issue.

The folate fortification program has increased concentrations of serum and RBC folate in the entire population and substantially eliminated folate deficiency in the US.³¹ Our study has shown that nutrient supplement users and nonusers did not differ in dietary folate intake at baseline, however nutrient supplements users had higher serum and RBC folate concentrations and better folate status than nonusers. This suggests that nutrient supplements may have a beneficial effect on folate status although there was limited information collected about the types of supplements taken by subjects in the survey. This study also showed that serum folate, but not RBC folate, of schoolchildren who did not take nutrient supplements increased with dietary folate intake, consistent with the fact that serum folate is highly influenced by current dietary intake.¹¹ RBC folate levels were also positively correlated with serum folate levels ($r = 0.6501$, $p < 0.0001$) in our study, suggesting that recent folate status may be associated with long term folate status.^{36,37} Our results showing a higher prevalence of folate deficiency evaluated by RBC folate level than by serum folate level indicate that the folate status of schoolchildren needs to be improved.

In summary, this study provides information on the folate status of Taiwanese schoolchildren. Boys had poorer folate status than girls. It should be noted that up to 32% of boys and 27% of girls had serum folate insufficiency, and 25% of children had RBC folate insufficiency. In addition, 42% of Taiwanese schoolchildren had inadequate folate intake. Those who took nutrient supplements had significantly better serum and RBC folate status. Those who did not take nutrient supplements had higher serum folate levels, but not RBC folate levels, with increased folate intakes. This study suggests that the folate status of Taiwanese schoolchildren is inadequate, and is particularly poor in those children entering adolescence. It is important to prevent the development of folate insufficiency in this potentially vulnerable population.

ACKNOWLEDGEMENTS

This study was supported by the Department of Health, Taiwan (DOH 95-TD-F-113-030). Data analysed in this paper were collected by the research project "Nutrition and Health Survey in Taiwan (NAHSIT)" sponsored by the Department of Health in Taiwan (DOH-88-FS, DOH89-88shu717, DOH90-FS-5-4, DOH91-FS-5-4). This research project was carried out by the Institute of Biomedical Sciences of Academia Sinica and the Research Center for Humanities and Social Sciences, Center for Survey Research, Academia Sinica, directed by Dr. Wen-Harn Pan and Dr. Su-Hao Tu. The Center for Survey Research of Academia Sinica is responsible for data distribution. The assistance provided by the institutes and aforementioned individuals is greatly appreciated. The views expressed herein are solely those of the authors.

AUTHOR DISCLOSURES

Kuan-Ju Chen, Ning-Sing Shaw, Wen-Harn Pan, and Bi-Fong Lin, no conflicts of interest.

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Original Article

Evaluation of folate status by serum and erythrocyte folate levels and dietary folate intake in Taiwanese schoolchildren

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臺灣地區國小學童葉酸營養狀況評估

本研究以衛生署 2001-2002 年進行的「臺灣地區國小學童營養健康狀況調查 2001-2002」(Nutrition and Health Survey in Taiwan Elementary School Children 2001-2002; NAHSIT Children 2001-2002)計畫中的 6~13 歲學童為研究對象，男生 1105 人和女生 958 人，共計 2063 人，以全自動冷光分析儀測定血清與紅血球葉酸濃度。結果顯示，男生血清葉酸濃度為 18.3 ± 8.8 nmol/L (8.1 ± 3.9 ng/mL)，女生為 20.3 ± 9.7 nmol/L (9.0 ± 4.3 ng/mL)；男生紅血球葉酸濃度為 700 ± 320 nmol/L (308 ± 141 ng/mL)，女生為 751 ± 347 nmol/L (331 ± 153 ng/mL)。男女生各有 1.4% 為血清葉酸缺乏；血清葉酸瀕臨缺乏比率男生為 31.1%，女生為 25.8%。紅血球葉酸缺乏比率男生為 8.5%，女生為 7.4%。男女生之紅血球葉酸瀕臨缺乏比率為 17%。尤其是男生在 12~12.9 歲、女生在 11~12.9 歲正值進入青春發育期的葉酸營養狀況最差。每日飲食葉酸攝取量，男生平均為 269 ± 9 μ g，女生為 259 ± 9 μ g，有將近 42% 的男女生飲食葉酸攝取量尚未達到 2/3 的飲食建議攝取量。研究顯示正值進入青春期的臺灣國小學童葉酸營養狀況不佳，應加以改善。

關鍵字：飲食葉酸、血清葉酸、紅血球葉酸、國小學童、「臺灣地區國小學童營養健康狀況調查 2001-2002」。