Original Article

Micronutrient status of primary school girls in rural and urban areas of South Vietnam

Ta thi Tuyet Mai MD, PhD[1,2], Nguyen thi Kim Hung MD[2], Masanobu Kawakami MD, PhD[3], Mari Kawase BSc[1] and Nguyen van Chuyen PhD[1]

[1] *Department of Food and Nutrition, Japan Women's University, Tokyo, Japan*
[2] *Child Nutrition Centre, Ho Chi Minh City, South Vietnam*
[3] *Department of Medicine, Jichi Medical School, Saitama, Japan*

Dietary habits, especially micronutrient intake, and nutritional status of Vietnamese primary school girls were investigated in a cross-sectional survey. We interviewed 284 girls aged 7 to 9 years old, randomly selected from three rural (N=148) and two urban (N=136) primary schools. Dietary data were calculated from the results of 24-h recall interviews over three consecutive days. The dietary micronutrient pattern of the rural group showed deficiency of iron, calcium, phosphorus, potassium, magnesium, beta-carotene, vitamin A and vitamin C. On the contrary, adequate consumption of these elements, except low beta-carotene, was observed in the urban group. Despite a low prevalence of anaemia, the prevalence of rural children with iron deficiency was close to the level regarded as being a public health problem. In contrast, 7.7% of urban children were found to have excessive iron status. Children with exhausted retinol stores (7.1%) requiring immediate retinol supplementation were only found in the rural group. Furthermore, the prevalence of children with marginal retinol stores in both the rural (35.7%) and urban (21.4%) groups was above the level of being a public health problem (20%). In both groups, more than 50% and 20% of children showed beta-carotene and tocopherol levels in the range of severe deficiency, respectively. Thus, nutritional education to improve the dietary habits of the two groups is necessary for Vietnamese primary school children.

Key Words: Primary school girl, Ho Chi Minh city, Vietnam, micronutrient dietary intake, biochemical parameter, rural, urban

Introduction

Micronutrients such as vitamins and minerals play an important role in the promotion of health and prevention of disease.[1] To date, approximately 2 billion people in the world suffer from micronutrient malnutrition, and 85% of them reside in developing countries.[2]

School age is a period of life characterized by high speed of growth. Dietary patterns acquired during this period are likely to be continued into adulthood.[3] Moreover, poor nutrition, especially iron deficiency in school-age children, is associated with retardation of growth and cognitive development.[4] Therefore, the school age represents a period of high concern.

About 46% of 5-14 year-old children in the world are afflicted with iron deficiency.[2] A study of eight African and Asian countries found that 40-60% of school children aged 7-11 in Mali, Tanzania, Mozambique, Ghana, Malawi, and Kenya and 30% of those in Indonesia suffered anaemia.[5] Retinol deficiency was found in 34.7% of Kwazulu-Natal school children.[6] Multi-micronutrient deficiency was found in a high percentage of Turkish school-age children.[7] Information on the nutritional status of school-age children in Vietnam is very limited. The micronutrient nutritional status, first reported in the 1995 National Anaemia Survey, showed 11% of children aged 8-14 years suffered from anaemia.[8] Previously, we reported the macronutrient status of Vietnamese primary school girls.[9] The present paper deals with their micronutrient status based on both dietary intake and bio-chemical measurements. This information will contribute to identifying all the factors affecting children's health, and as a result, could help determine the best way to carry out nutritional intervention in Vietnamese children.

Methods

Study sample

A cross-sectional survey was conducted from October 1 to November 1, 1999. Binh Chanh district was randomly selected from 10 rural districts, and the First district from 12 urban districts of Ho Chi Minh City. Then, 3 of 51 schools in

Correspondence address: Professor Nguyen van Chuyen, Department of Food and Nutrition, Japan Women's University Mejirodai 2-8-1, Bunkyo-ku, Tokyo 112-8681, Japan.
Tel: + 81-3-5981-3430; Fax: + 81-3-5981-3426
Email: nvc@fc.jwu.ac.jp
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the Binh Chanh district and 2 of 36 schools in the First district were randomly selected. From a list of 2848 primary school girls between 7 and 9 years of age, 351 girls were randomly selected for the survey. Binh Chanh district is a low-income rural area, in which most people are farmers or fishermen. The First district is a high-income trading area, where the majority of people are traders. Overall, 35.8% of the children were aged 7, 35.2% were aged 8 and 29% were aged 9 in the rural group. In the urban group, the percentages were 36.1%, 34.2% and 29.7%, respectively.

In the rural group, one child was found to have urethro-rectalostoma disease. In the urban group, one child had suffered urinary tract infections, and another child had a history of hepatitis. In addition, 45 children in rural and 19 children in urban areas suffered from worm infestation. These 67 children were all excluded from this survey. All 148 rural and 136 urban children participated with parental consent.

Data collection

Food intake

Twenty-four-hour dietary intake recall interviews were conducted and repeated every day for three consecutive days by trained interviewers. A common set of household measures, photographs and/or pictures of food were used to facilitate the estimation of portion size. All of the interviewers were medical doctors working at the Ho Chi Minh Child Nutrition Center. Parents or caregivers of the children were asked to attend 24-h dietary recall interviews for three consecutive days. The parents and their children were asked to recall all food consumed by the child during the previous day.

The 24-h dietary recall data were used to calculate dietary energy and nutrient intake using Excel Eiyokun, version 08.E, developed by Dr. Yukio Yoshimura, Shikoku University, Japan. Excel Eiyokun data were obtained from the Nutritive Composition Table of Vietnamese Foods.[10] Since vitamin D and tocopherol quantity are not included in the "Nutritive composition table of Vietnamese foods",[10] in this survey we only calculated iron, potassium, magnesium, calcium, phosphorus, retinol and beta-carotene intake. On the basis of the influence of iron absorption enhancers (IAE) such as ascorbic acid, cooked meat, fish and poultry, we calculated the amount of absorbable dietary iron (AbI) by the method of Monsen *et al.*[11]

The Vietnamese Recommended Dietary Allowances (Vn-RDA)[12] were used as the standard to estimate the nutrient intake status. However, Vietnamese standards for absorbable iron and beta-carotene consumption have not yet been established, so we had to use the WHO standards.[13,14] "The food needs for Vietnamese" established by the Vietnam Institute of National Nutrition[15] was used to evaluate the proper food consumption in this survey.

Biochemical analysis

Blood samples were collected from each participant on the third day of the interview and were used for measurement of biochemical data. Haematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) were determined by a Cell Dyn 3200 (Abbott Diagnostics, Vietnam). These analyses were conducted at the Diagnostics Center, Ho Chi Minh City, Vietnam. Other biochemical parameters were analyzed by the Analytic Section of the Department of Medicine, Jichi Medical School. Briefly, the analytical methods were as follows: serum iron (SI) and unsaturated iron binding capacity (UIBC) were measured by an automated method using a Techicon-H 6000 analyzer, total iron binding capacity (TIBC) and transferrin saturation (TS) were calculated using the following equations: TIBC = (UIBC + SI); TS=(SI/TIBC) × 100.[16] `Serum calcium (Ca) was determined using O-cresolphthalein complexone (SRL, Inc., Japan).

Serum phosphorus (P) was measured using a Gilford 240 spectrophotometer at a wavelength of 660 nm. Serum alkaline phosphatase (ALP) was measured with an automatic analyzer (model 704 Hitachi, Tokyo, Japan) using a reagent kit (Boehringer, Mannheim, Germany). Magnesium (Mg) was measured by ion-selective electrodes on a parallel multi-channel analyzer (Shinotext Co., Tokyo, Japan). Retinol, beta-carotene and tocopherol were simultaneously determined by high performance liquid chromatography (HPLC, Shimadzu 10A, Tokyo, Japan). In brief, vitamins were extracted with ethanol and hexane: the hexane phase was evaporated under nitrogen gas, and the residue was dissolved in ethanol. Vitamins were separated by a reversed-phase HPLC: column, NH_2-1251-N, 4.6 ∅ × 250 mm (SSC, Co.); mobile phase, hexane: 2-propanol (97:3); flow rate, 1 ml/min; detection, UV 325 nm for retinol (Shimadzu SPD-10A detector), VIS 450 nm for beta-carotene (Shimadzu SPD-6AV detector), fluorescence 297nm excitation and 327nm emission for tocopherol (Shimadzu RF-10A detector).

The cut-off points for the classification of retinol, beta-carotene, and tocopherol deficiency were referenced from the "Handbook of Clinical Dietetics",[16] and the classification of Mg deficiency was referenced from "Magnesium Status and Health".[17] Serum Ca×P and ALP were used as indicators of vitamin D status.[18]

Statistical analyses

Statistical analyses were performed using SPSS for Windows (Statistical Package for Social Sciences, version 6.0 1996; SPSS, Inc., Chicago, USA). Independent sample t-test and chi-squared test were conducted to evaluate differences in median and prevalence data between the rural and urban groups. Odds ratios (OR) were calculated by logistic regression models.

Ethical considerations

Parents of the participating children were informed of the purpose of this survey. Assurance was given that cooperation was voluntary. The survey proposal was approved by the Research and Ethical Review Board of the Ho Chi Minh Child Nutrition Center.

Results and Discussion

In order to clarify the micronutrient nutritional status among Vietnamese school-age girls, we analyzed the differences in micronutrient consumption and status of primary school children between urban and rural areas.

Iron stores and dietary iron consumption

Iron stores

Iron is a double-edged sword, essential to life in moderation but harmful in excess.[19] School-age children are at risk of iron deficiency because of an expanding red cell and muscle mass.[19]

Deficient iron stores

In this survey, we evaluated two stages of deficiency of iron stores: 1) metabolic iron deficiency indicated by low TS (<15%) or low SI (<10.7 μmol/L), and 2) clinical iron deficiency anaemia indicated by a fall in haemoglobin (Hb) (< 7.1 mmol/L) and MCV (< 76%).[19] The mean values of these indicators were in the normal range in both groups (Table 1). However, the prevalence among rural children of TS less than 15% (16.1%) and SI less than 10.7 μmol/L (24.3%) (Table 2) was close to the level regarded as being a severe public health problem (20-25%)[20] (Table 2). These results revealed that metabolic iron deficiency affected a large proportion of rural children.

Low Hb and MCV, indicators of clinical iron deficiency anaemia, which were found in 3.7% and 10.2% of rural children (Table 2), showed clinical iron deficiency anaemia still not to be a health concern in this population. A similar situation was also found in Arabian (Arab) school children, with 8.5% of children suffering from anaemia (Hb <7.1 g/L) but 26.3% of children with depleted iron stores (SI <10 μmol/L).[21] It is well known that an early stage of iron deficiency affects iron content distribution, resulting in neurotransmitter and brain metabolic alteration, then impairment of psychomotor development and cognitive function,[22] which consequently hinders the ability of children to learn.[4] For that reason, iron supplementation must be a viable approach for rural children. Both metabolic iron deficiency and clinical iron deficiency anaemia were not a significant health problem in the urban group, with only 4.5% of children having TS less than 15% and 2% with Hb less than 7.13 mmol/L (Table 2).

Excessive iron stores

There are two stages of positive iron balance; TS >45% and SI >26.9 μmol/L indicate excessive iron stores; and TS >60% and SI >31.3μmol/L are signs of iron overload.[19] Both excessive iron stores (TS >45%) and iron overload (TS >60%) were found in 7.7% and 1.3% of urban children, respectively (Table 2). This prevalence was close to the

Table 1. Serum biochemical data of 7-9 year-old school children in rural and urban areas

	Normal Range	Rural (N=148) Mean ± SD	Urban (N=136) Mean ± SD
Iron store data[a]			
Serum iron (μmol/L)	10.7 - 26.9	14.4 ± 5.7	17.6 ± 6.6**
Total iron binding capacity (μmol/L)	43.0 - 68.0	62.6 ± 4.7	63.5 ± 7.9
Transferrin saturation (%)	15.0 - 45.0	24.7 ± 9.8	29.5 ± 11.6**
Haemoglobin (mmol/L)	> 7.1	8.1 ± 0.6	8.4 ± 0.6**
Haematocrit (%)	> 36.0	38.6 ± 2.7	39.6 ± 2.5
Red blood cell count ($\times 10^{12}$/L)	4.2- 4.8	4.8 ± 0.4	4.9 ± 0.4
Mean corpuscular volume (%)	80.0 - 95.0	81.3 ± 6.2	82.0 ± 6.0
Mean corpuscular haemoglobin (pg)	26.0 - 32.0	27.6 ± 2.0	27.7 ± 2.4
Mean corpuscular haemoglobin concentration (g/l)	310.0 - 360.0	338.4 ± 10.2	340.3 ± 7.5
Vitamin D status[b]			
Serum calcium × phosphorus (mg/L)	>400.0	474.4 ± 54.5	528.2 ± 69.8**
Alkaline phosphatase (King-Armstrong units/L)	80.0 - 140.0	93.7 ± 52.1	101.7 ± 24.9*
Magnesium[c]			
Magnesium (mmol/L)	0.78 - 1.0	0.87 ± 0.09	0.86 ± 0.08
Other vitamins[d]			
Retinol (μmol/L)	0.7 - 1.05	0.96 ± 0.46	1.16 ± 0.70*
Beta carotene (μmol/L)	>1.37	0.91 ± 1.19	0.56 ± 0.35*
Tocopherol (μmol/L) (To)	12.0 - 24.0	7.4 ± 4.6	9.0 ± 4.6*
Tocopherol / (Cholesterol + Triacylglycerol) (μmol/mmol)		1.48 ± 0.91	1.63 ± 0.83

[a]Referenced from "Everyone should be tested for iron disorder"[19]; [b]Referenced from "Harrison's Principles of Internal Medicine"[18]; [c]Referenced from "Magnesium Status and Health"[17]; [d]Referenced from "Handbook of Clinical Dietetics".[16] *P<0.05, **P<0.001, for urban versus rural group.

prevalence of Americans suffering excessive iron stores (10%) and iron overload (1%).[19] About 10% of Americans have a gene for the enhancement of iron absorption, which results in 10% of Americans having excessive iron stores.[19] Excess iron is reported to damage internal organs and promote cancer and other disorders via excess iron-catalyzed oxidation.[23] Therefore, the control of iron deficiency in rural areas and an effective approach to protect Vietnamese urban children from the risk of iron overload is a concern in Vietnamese nutritional intervention.

Dietary iron consumption

The consumption of both total and absorbable iron in the rural group did not meet the RDA of World Health Organisation (WHO) (Table 3). Furthermore, 61.1% of rural children had absorbable iron below the lower limit of the WHO-RDA (Table 4). It appears that in the rural group, there was a state of low total iron intake. Meat and fish, a rich source of heme iron and the enhancing factors for non-heme iron absorption, were consumed in low quantity in the rural group (Table 3). Moreover, insufficient consumption of vitamin C, an IAE, was also found in the rural group, which might result from the low consumption of fresh fruit and vegetables (Table 3). Urban children consumed above the upper limit of the WHO RDA of both total iron and AbI (Table 3). Moreover, 63.2% of urban children consumed more than 1.2 mg AbI/d (Table 4). It is well known that excessive absorbable iron consumption might promote progression of the excessive iron store stage to the iron overload stage.[19] Therefore, the iron consumption of the 7.7% of children with excessive iron stores must be controlled.

Table 2. Percentage of rural and urban children with biochemical values above or below the recommendation or normal range

	Rural (N=148)	Urban (N=136)	P^1	Odds ratio[2] (95% CI)
Recommended value	% of subjects			
Iron stores[3]				
Negative iron balance				
Iron depletion (second stage)				
Transferrin saturation < 15%	16.1	4.5	0.001	4.0 (1.7-9.5)**
Serum iron < 10.7 µmol/L	24.3	7.3	0.000	3.3 (1.7-6.4)***
Iron-deficiency anaemia (last stage)				
Haemoglobin < 7.13 mmol/L	3.7	2.0	ns	1.9 (0.5-7.5)
Mean corpuscular volume <76 %	10.2	9.0	ns	1.1 (0.6-1.8)
Positive iron balance				
Excessive iron				
Transferrin saturation > 45%	1.0	7.7	0.001	0.1 (0.02-0.6)*
Serum iron > 26.9 µmol/L	0.5	7.7	0.000	0.1 (0.01-0.5)*
Iron overload disease				
Transferrin saturation > 60%	0.5	1.3	ns	0.4 (0.04-4.4)
Serum iron > 31.3 µmol/L	0.5	3.2	0.048	0.2 (0.02-1.4)
Magnesium [4]				
Magnesium < 0.78 mmol/L	23.3	25.2	ns	0.9 (0.6-1.5)
Vitamin D [5]				
Serum Calcium × Phosphorus < 400 mg/L	7.3	1.9	0.016	4.0 (1.1-14)*
Alkaline phosphatase >400 King-Armstrong units/L	5.0	0.0	ns	Nc
Other vitamins [6]				
Serum retinol < 0.35 µmol/L	7.1	0.0	0.008	Nc
Serum retinol < 0.7 µmol/L	35.7	21.4	ns	2.0 (0.96-4.3)
Serum beta-carotene < 0.7 µmol/L	58.6	68.6	ns	0.6 (0.3-1.3)
Tocopherol < 4.8 µmol/L	27.1	20.0	ns	1.5 (0.7-3.3)
Tocopherol/ (cholesterol + triacylglycerol) <2.36*	100.0	100.0	ns	1.0 (1.0-1.0)

[1]Significant difference in levels between rural and urban group calculated by chi-squared statistical analysis. [2]Odds ratio and 95% confidence intervals (CI) were calculated from logistic regression models. [3]Referenced from “Everyone should be tested for iron disorder”[19]; [4]Referenced from “Magnesium status and Health”[17]; [5]Referenced from “Harrison’s Principles of Internal Medicine”[18]; [6]Referenced from "Handbook of the Dietetic Association"[16]; [6]Referenced from "Comparison of serum concentration of tocopherol and β-carotene in a cross-sectional sample of obese and non-obese children".[32]
ns, not significant; nc, odds ratio was not calculated because number of subjects was too small. *$P < 0.05$, **$P < 0.005$, ***$P < 0.001$

Table 3. Micronutrient intake of rural and urban school-age girls in comparison with Vietnamese RDA

	Recommended intake[a]	Rural (N=148) Mean ± SD	Urban (N=136) Mean ± SD
Micronutrients[a]			
Total iron (mg/d)	12.0	10.4 ± 3.6	13.5 ± 3.7**
Heme iron (mg/d)	–	0.75 ± 0.81	1.43 ± 0.71**
Total absorbable iron (mg/d)[1]	0.94 - 1.2	0.93 ± 0.41	1.33 ± 0.41**
Heme absorbable iron (mg/d)	–	0.17 ± 0.86	0.33 ± 0.16**
Calcium (g/d)	0.5	0.34 ± 0.16	0.66 ± 0.39**
Phosphorus (mg/d)	0.8	0.58 ± 0.14	0.94 ± 0.25**
Calcium / Phosphorus ratio	0.2 - 2.0	0.58 ± 0.20	0.68 ± 0.26**
Calcium / Magnesium ratio	2.0	4.5 ± 2.9	4.8 ± 2.6
Magnesium (mg/kg body)	6.0	4.7 ± 3.1	5.4 ± 2.5
Potassium (g/d)	1.2	0.9 ± 0.3	1.2 ± 0.3**
Retinol (mg RE)	-	0.13 ± 0.22	0.26 ± 0.18**
Beta-carotene[2] (mg/4.2 MJ)	2.1	1.09 ± 0.96	0.61 ± 0.40**
Retinol + beta carotene /6 (mg RE)	0.4	0.36 ± 0.42	0.44 ± 0.30*
Ascorbic acid (mg/d)	55.0	53.3 ± 39.9	70.7 ± 42.0**
Foods[b]			
Meat (g/d)	60.0	39.1 ± 31.0	132.5 ± 60.3**
Fish (g/d)	55.0	47.3 ± 36.9	38.8 ± 37.7*
Milk (ml/d)	220.0	15.7 ± 34.9	130.2 ± 151.4**
Green yellow vegetables (g/d)	85.0	35.8 ± 44.7	77.0 ± 64.6*
Nuts and seeds (g/d)	32.0	3.2 ± 8.0	5.8 ± 8.0**
Fruit and juice (g/d)	160.0	95.2 ± 93.4	118.1 ± 84.6*
Vegetable oil (g/d)		4.3 ± 6.6	18.0 ± 9.8**

[a]Referenced from "Vietnamese Recommended Dietary Allowances" [12]; [b]Referenced from "Food needs for Vietnamese".[15]
[1]Referenced from WHO 1988[13]; [2]Referenced from WHO 1998[14]; *P<0.005 **P<0.001 for urban versus rural group.
All values were calculated based on three consecutive days of 24h recall interviews.

Potassium

In this survey, we only assessed the potassium status through dietary intake. Potassium consumption in the urban group was significantly higher than that in the rural group and met the Vn-RDA, but that in the rural group did not (Table 3). The low consumption of fruit and vegetables, a rich source of potassium, might contribute to the inadequate consumption of potassium in the rural group (Table 3). Increased dietary potassium intake has been reported to prevent the development of hypertensive cardiovascular disease,[24] lower total cholesterol (TC), triglycerides (TG), and LDL-cholesterol and increase HDL-cholesterol.[25] The formation of fatty streaks or initial lipid deposits in the aorta begins at 3-4 years of life,[26] so that sufficient potassium consumption might be necessary for rural children.

Magnesium and Calcium/Magnesium ratio

Mg participates in all major metabolic pathways and is an obligatory factor for DNA synthesis. Mg deficiency gives rise to a very broad syndrome such as growth failure.[17] The mean Mg concentration was in the normal range in both the rural and urban groups (Table 1). However, more than 20% of children in both groups had a serum Mg concentration below 0.78 mmol/L (Table 2), which is considered to reflect the start of a hypomagnesium state.[17] Low Mg consumption and a high Ca/Mg ratio also characterized the dietary pattern of both groups (Table 3). A high ratio of Ca/Mg might reduce the efficiency of Mg absorption, reduce the movement of Mg into bone and increase the activity of the demineralizing parathyroid hormone.[17] Therefore, higher consumption of food rich in Mg such as low-grade polished rice, vegetables, and fruit should possibly be encouraged in children of both groups.

Vitamin D status and Calcium, Phosphorus consumption

Vitamin D

The mean of two indicators of vitamin D status; serum Ca×P and ALP, was within the normal range [18] in both groups (Table 1). In the rural group, 5% of children had an ALP value higher than 400 King-Armstrong units/L and 7.3% of children had serum Ca×P less than 400 mg/L (Table 2). Only

1.9% of children had a serum Ca×P under 400 mg/L in the urban group (Table 2). These results showed that vitamin D deficiency seemed not to be a health problem in either group. Vietnam, a subtropical region, has the advantage of having plenty of sunlight throughout the year. Thus, this environmental condition might contribute to school children obtaining vitamin D through exposure to sunshine.

Calcium and Phosphorus consumption
The mean value of Ca, P consumption met the Vn-RDA[12] in the urban but not in the rural group (Table 3). About 90% of rural children had Ca, P consumption below the Vn-RDA (Table 4). Low consumption of food rich in Ca such as milk and dairy products (10% of Vn-RDA), nuts (10% of Vn-RDA), and fish (85% of Vn-RDA) was the main reason for low Ca consumption in the rural group (Table 3). Low Ca consumption resulting in low bone mineral concentration (BMC) and bone mineral density (BMD) was reported in 7 year old Chinese children who consumed 0.34 g Ca/day.[27] Thus, the risk of low BMC and BMD must be a concern in rural children.

Retinol
Retinol status
Retinol is an important nutrient for the gene expression of growth hormone, indicated by an improvement in linear growth of children who received retinol supplements.[1] In our survey, serum retinol was in the normal range in both groups (Table 1). However, exhausted retinol stores (<0.35 μmol/L) were found in 7.1% of rural children (Table 2). In addition, 35.7% of rural and 21.4% of urban children exhibited marginal retinol stores (0.35-0.7 μmol/L) (Table 2). This prevalence is higher than the level regarded as being a severe public health problem of retinol deficiency (20%).[28]

In comparison with other developing countries, the mean serum retinol in Vietnamese primary school girls was close to that in Chinese 5-9 year-old school girls (1.05 μmol/L)[29] but much lower than that in Turkish children (1.33 μmol/L).[7] However, the percentage of rural children with marginal retinol stores (serum retinol < 0.7 μmol/L) in this survey was triple that of Turkish (9.3%)[7] and close to that of South African 8-10 year-old school-age children (34.7%).[6] These results reveal that vitamin A deficiency is a severe health concern in both the rural and urban groups.

Retinol intake
Adequate total vitamin A consumption was found in the urban but not in the rural group (Table 3). Furthermore, insufficient vitamin A consumption was observed in both the rural (72.5%) and urban (31%) populations (Table 4). Low intake of meat, eggs, and milk (Table 3) may be the reason for the high prevalence of children with low total vitamin A consumption in the rural group. In addition, a lack of knowledge on selection of retinol- or pro-vitamin A-rich food sources might contribute to the high prevalence of children with inadequate vitamin A consumption in both the urban and rural groups.

Beta- carotene
Beta-carotene status
Serum beta-carotene in rural children (0.91 μmol/L) was double that in urban children (0.56 μmol/L), but below the normal range (1.37 μmol/L) (Table 1). It was lower than that in female Arab children (2.9 μmol/L)[30] and Turkish children (2.3 μmol/L).[7] This phenomenon shows serum beta-carotene in Vietnamese children of school age to be in the low range compared to levels in other developing countries.

Beta-carotene intake
Inadequate beta-carotene consumption was found in both groups, but was more severe in the urban group (Table 3). In this survey, beta-carotene consumption of urban children was only one third the WHO-RDA (0.61 vs. 2.1 mg/ 4.2 MJ), while their consumption of green and yellow vegetables, the

Table 4. Percentage of rural and urban children who did not meet the micronutrient recommendation

Recommended values[3]	Rural (N=193)	Urban (N=155)	P^1	Odds ratio[2] (95% CI)
	% of subjects			
Absorbable iron < 0.94 mg/d[a]	61.1	14.2	0.000	9.5 (5.6-16.3)*
Absorbable iron > 1.2 mg/d[a]	17.6	63.2	0.000	0.1 (0.1-0.2)**
Calcium < 0.5 g/d	88.1	39.4	0.000	11.4 (6.6-19.6)**
Phosphorus < 0.8 g/d	93.3	29.0	0.000	33.8 (17.5-65.6)**
Magnesium < 6 mg/kg body	74.6	61.9	0.011	1.8 (1.1-2.9)*
Calcium / Magnesium ratio > 2.0	88.1	97.4	0.001	0.2 (0.1-0.6)*
Potassium < 1.2 g/d	80.0	55.5	0.000	3.4 (2.1-5.5)**
Vitamin C < 55 mg/d	64.2	41.9	0.000	2.5 (1.6-3.8)**
Total vitamin A < 0.4 mg/d	72.5	31.0	0.000	5.9 (3.7-9.4)**
Beta-carotene < 2.1 mg/ 4.2 MJ[b]	89.6	94.8	ns	0.5 (0.2-1.1)

[1]Significant difference in levels between rural and urban group calculated by chi-squared statistical analysis. [2]Odds ratios and 95% confidence intervals (CI) were calculated from logistic regression models. [3]Referenced from "Vietnamese Recommended Dietary Allowances"[12]; [a]Referenced from WHO 1988[13]; [b]Referenced from WHO 1998[14]. ns: not significant. *P < 0.005; **P < 0.001,

main source of beta-carotene, was not much lower than the Vn-RDA (77 vs. 85 g/d) (Table 3). It seems that the Vn-RDA for green and yellow vegetables must be increased in Vietnamese children in order to ensure adequate beta-carotene consumption.

Tocopherol

Tocopherol plays an important role in the prevention of cardiovascular disease.[1] Deficiency of tocopherol might lead to a decrease of retinol in serum and tissue.[31] Both serum tocopherol (To) and To/ (TC + TG) ratio of Vietnamese school girls (Table 1) were only one third those of Turkish (21.9 μmol/L and 6.3 μmol/mmol),[7] and half those of American children (18.0 μmol/L and 3.2 μmol/mmol)[32] and in the low range of the global standard for tocopherol.[16] A low consumption of tocopherol-rich food sources such as nuts and green vegetables in the two groups and vegetable oil in the rural group (Table 3) might explain the low serum tocopherol in both populations.

Conclusion

From this survey, we found that metabolic iron deficiency was a health problem in the rural group, while a rather high proportion of urban children were found to have a positive iron balance. Retinol deficiency was a health concern in both groups, but was more severe in the rural group. Severe deficiency of beta-carotene intake, being one-third the World Health Organisation RDA for beta-carotene consumption, underscoring the importance of low vegetable consumption. In addition, severe tocopherol deficiency was also a health concern in both groups. Nutritional education to improve the micronutrient intake is considered to be necessary for Vietnamese school-age children.

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