行政院國家科學委員會補助專題研究計畫成果報告

探討年輕素食者與非素食者蛋白質攝取對維生素 B-6 營養狀況的影響

The effect of animal- and plant-protein on vitamin B-6 status in young adult vegetarians and nonvegetarians

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一、中文摘要

本研究計劃的目的是調查並比較年輕素食者及非素食者維生素 B-6 的攝取量及營養狀況，進一步探討飲食因子對 B-6 生化指標的影響。13 素食者及 26 位非素食者參與本研究。平均維生素 B-6 攝取量(素食: 1.03 ± 0.39 mg/d; 非素食: 1.05 ± 0.47 mg/d)均低於美國飲食參考攝取量及台灣飲食建議攝取量。能量、蛋白質、及維生素 B-6 和維生素營養生化指標並無相關性。但是飲食纖維則顯著與血球丙胺酸轉胺酵素活性系數 ($r = -0.59$, $p < 0.05$)成負相關。素食組比起非素食者有顯著較低的磷酸比哆醛及尿液比哆酸濃度。蛋白質來源(動物 vs.植物)對維生素 B-6 營養狀況並無影響；但是飲食纖維對維生素 B-6 營養狀況則有顯著影響。素食者若能增加維生素 B-6 的攝取應能改善其維生素 B-6 的營養狀況。

關鍵詞：維生素 B-6，磷酸比哆醛，比哆酸，蛋白質，素食者

Abstract

The purpose of this study was to assess vitamin B-6 status of vegetarians and nonvegetarians, and to examine the nutrient factors in vegetarian diets on various indices of vitamin B-6 status. Thirteen vegetarian and 26 nonvegetarians participated in this study. The mean total vitamin B-6 intake (vegetarians: 1.03 ± 0.39 mg/d; nonvegetarians: 1.05 ± 0.47 mg/d) was lower than the 1998 US Dietary Reference Intakes (DRI) and the current Taiwan Recommended Daily Nutrient Allowance (RDNA). Dietary energy, protein, and vitamin B-6 intakes were not related to any vitamin B-6 status parameters in both groups. However, dietary fiber intake was significantly negatively correlated with EALT-AC ($r = -0.59$, $p < 0.05$) but not with EAST-AC in the vegetarian group. The vegetarian group showed significantly lower mean plasma pyridoxal 5'-phosphate (PLP) and urinary 4-PA concentrations than the nonvegetarian group. The source of dietary protein (plant- vs. animal-) had no effects on vitamin B-6 status parameters; however, dietary fiber did have an effect on the vitamin B-6 status. Vegetarian subjects increase their B-6 intakes or take supplementation might improve their vitamin B-6 status.

Keywords: vitamin B-6, pyridoxal-5'-phosphate, pyridoxic acid, protein, vegetarians

Introduction

Vitamin B-6 is essential for the metabolism of tryptophan and the sulfur-containing amino acids (i.e., methionine). A vegetarian diet containing only plant proteins which low in these amino acids, may reduce the requirement of vitamin B-6.

Pyridoxal-5'-β-D-glucoside (PNG) is a major form of vitamin B6 in plant foods. The bioavailability of PNG has been documented to be as low as 50-58% of the bioavailability of free pyridoxine (Gregory *et al.* 1991; Nakano *et al.* 1997).

In addition to the PNG content in the plant foods, dietary fiber might be another factor to compromise the bioavailability of vitamin B-6.

Purposes

The purpose of this study was to assess and compare the vitamin B-6 status between vegetarians and nonvegetarians. The effects of the source of protein and fiber content on vitamin B-6 status were also examined.

Subjects and methods

Subjects. Vegetarian and nonvegetarian young adults were recruited from the university campus and the community in Taichung city by advertisements. Demographic and health data were collected and weight and height were measured. A fasting blood sample was obtained for clinical chemistry evaluation.

Thirteen vegetarians and 26 nonvegetarians were recruited in this study. Subjects' characteristics are summarized in Table 1. Informed consent was obtained from each subject. The study protocol was approved as ethical when the research proposal was reviewed by the Chung Shan Medical University.

Method. All subjects were given instruction on how to complete a 3-d dietary record. Nutrient composition of the 3-d records was calculated using the food composition table (Department of Health, Taiwan, 1994).

Once the dietary record had been completed, fasting venous blood samples were obtained to estimate hematological and vitamin B-6 status parameters. Plasma and erythrocytes were prepared as previously described (Woodring & Storvick, 1970) and then stored frozen (- 20° C) until analysis. Plasma PLP were determined by HPLC according to the method as previously described (Bates *et al.* 1999). Erythrocyte alanine aminotransaminase and erythrocyte EAST with and without PLP stimulation in vitro were measured by the method of Woodring and Storvick (1970). Twenty-four h urine collections were obtained on the third day of the dietary record. Twenty-four h urine volumes were determined and aliquots stored frozen (-20° C) until analyzed. Urinary 4-PA was analyzed by HPLC by the modified method as described by Kant et al. (1988).

Statistical analyses. Data were analyzed by using SigmaStat statistical software (version 2.03; Jandel Scientific, San Rafael, CA). Differences in subject characteristics, nutrient intakes and biochemical measurements between dietary groups were determined by use of the Student's t test. Pearson correlation coefficients were performed to assess the relationship between dietary variables and vitamin B-6 status parameters. Statistical results were considered to be significant at $p \leq 0.05$. Values presented in the text are means ± standard deviation (SD).

Results

Descriptive characteristics. Characteristics of vegetarian and nonvegetarian subjects are shown in Table 1. The two groups (vegetarian vs. nonvegetarian) were of comparable age and body size.

Dietary intakes. Nutrient intakes from the 3-d dietary records kept by the subjects were calculated (Table 2).

There was no significant difference in vitamin B-6 intake and the ratio of vitamin B-6 to protein (mg/g) between vegetarian

and nonvegetarian subjects. The mean vitamin B-6 intake of both vegetarians and nonvegetarians was lower than the US Dietary Reference Intakes (DRI) of 1.3 mg/d and the current Taiwan Recommended Dietary Nutrient Allowance (RDNA) of 1.6 mg/d for adult men and 1.4 mg/d for adult women. Ten vegetarians (76.9%) and 20 nonvegetarians (76.9%) had vitamin B-6 intakes less than the US DRI of 1.3 mg/d for men and women. However, the ratio of mg B6/g protein was above the recommendation of 0.016 mg B6/g protein for the nonvegetarian group. Vegetarians had a significantly higher dietary fiber intake than nonvegetarians.

Significant correlations were observed between vitamin B-6 and protein intakes ($r=0.57$, $p=0.003$), vitamin B-6 and energy intakes ($r=0.47$, $p=0.02$), and vitamin B-6 and dietary fiber ($r=0.44$, $p=0.02$) in the nonvegetarian group.

Biochemical analyses. Plasma PLP concentrations are shown in Table 3. Both groups had mean plasma PLP concentrations higher than a cutoff value of 20 nmol/L (Food and Nutrition Board, 2000; Lui et al. 1985). Vegetarian subjects had significant lower plasma PLP concentration than nonvegetarian subjects. None of subjects had plasma PLP concentrations below the suggested value of 20 nmol/L. Dietary energy, protein, fat, vitamin B-6, and fiber intakes were not related to plasma PLP concentrations in both groups.

The EALT and EAST with PLP added in vitro are also shown in Table 3. The mean EALT-AC and EAST-AC values were not significantly different between vegetarian and nonvegetarian groups. The mean EALT-AC was ≥ 1.25 in the two groups, which is the suggested value for adequate vitamin B6 status (Leklem, 1990). Similarly, the mean EAST-AC value of subjects was higher than the suggested value (<1.8) for inadequate vitamin B6 status (Leklem, 1990). Dietary energy, protein, fat, vitamin B-6 intakes were not related to EALT-AC and EAST-AC in both groups. Dietary fiber intake was significantly negatively correlated with EALT-AC ($r = -0.59$, $p < 0.05$) but not with EAST-AC in the vegetarian group.

The results of urinary 4-PA excretion are shown in Table 3. Vegetarians had significant lower mean urinary 4-PA concentration than nonvegetarians. The value was above 3.0 μmol/d which is considered to be associated with adequate vitamin B-6 status (Leklem, 1990) in the nonvegetarian group. However, the vegetarian group had an inadequate mean urinary 4-PA concentration (< 3.0 μmol/d). Plasma PLP concentration was significantly positively correlated with urinary 4-PA in the vegetarian ($r = 0.68$, $p < 0.01$) and nonvegetarian ($r = 0.72$, $p < 0.001$) groups.

Discussion

We did not find any significant relationship between these parameters in either vegetarian or nonvegetarian group. Our vegetarians consumed not very high amount of protein (1.36 g protein/kg BW for vegetarians, 1.1 g protein/kg BW for nonvegetarian); therefore, protein intake may not have been high enough to have an effect upon vitamin B-6 status.

Shultz & Leklem (1987) showed that vitamin B-6 status of vegetarians was not different from that of nonvegetarians. Although our vegetarians consumed the similar amounts of dietary protein and vitamin B-6 then nonvegetarians, vegetarians had significant lower plasma PLP and urinary 4-PA values and slightly higher EALT-AC and EAST-AC levels. Based on our above findings, it has therefore been hypothesized that the source of protein (plant- vs. animal-) might have effects on the vitamin B-6 status.

Our vegetarians did consume significantly higher dietary fiber than did nonvegetarians. Dietary fiber was also found to be negatively correlated with EALT-AC in the vegetarian group. Therefore, dietary fiber did have an effect on reducing the vitamin B-6 status.

The source of dietary protein (plant- vs. animal-) had no effects on vitamin B-6 status parameters. However, dietary fiber did have an effect on the vitamin B-6 status. Vegetarian subjects increase their B-6 intakes or take supplementation might improve their vitamin B-6 status.

計劃成果自評

本篇研究內容與原計畫相評有達成98%的相符程度，為素食者的人數未達成原計劃的提議，原因為素食者的志願者較難募集。但為了使此研究能發表於國際性的期刊，固將繼續招募素食者以使總素食者人數能達成40人。計劃執行者認為此研究的結果定能發表於SCI的期刊。

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Table 1. Descriptive characteristics of vegetarians and nonvegetarians

Characteristics	Vegetarian (n = 13)	Nonvegetarian (n = 26)
Age (y)	23.8 ± 2.8	22.9 ± 1.8
Height (cm)	162.5 ± 5.4	164.1 ± 5.5
Weight (kg)	54.4 ± 6.0	57.7 ± 8.3
Body mass index (kg/m^2)	20.6 ± 1.9	21.3 ± 2.3

Values are arithmetic means ± SD.

Table 2. Daily nutrient intakes of the vegetarians and nonvegetarians

Nutrients	Vegetarian (n = 13)	Nonvegetarian (n = 26)
Energy (kcal)	2513.0 ± 737.7[a]	1864.1 ± 423.2[b]
Carbohydrate (g)	374.0 ± 120.3[a]	243.7 ± 62.7[b]
(% total energy)	59.7 ± 6.8[a]	52.5 ± 7.2[b]
Lipid (g)	81.3 ± 33.3	71.0 ± 23.0
(% total energy)	28.6 ± 7.8[a]	34.1 ± 7.1[b]
Total protein (g)	74.5 ± 18.7	65.0 ± 20.5
(% total energy)	12.2 ± 2.4	13.9 ± 2.9
Vitamin B6 (mg)	1.03 ± 0.39	1.05 ± 0.47
B-6 to protein (mg/g) ratio	0.015 ± 0.005	0.016 ± 0.006
Dietary fiber (g)	21.4 ± 8.1[a]	10.5 ± 4.5[b]

Values are arithmetic means ± SD. Values in a row with different superscript letters are significantly different, $p \leq 0.05$

Table 3. Biochemical indices of vitamin B6 status of vegetarians and nonvegetarians

Indicator	Vegetarian (n = 13)	Nonvegetarian (n = 26)
Plasma		
Pyridoxal-5'-phosphate (nmol/L)	44.2 ± 13.6[a]	64.2 ± 26.7[b]
Erythrocyte		
EALT-AC	1.35 ± 0.60	1.25 ± 0.61
EAST-AC	1.91 ± 0.40	1.86 ± 0.29
Urinary		
4-pyridoxic acid (μmol/d)	1.93 ± 1.17[a]	3.26 ± 2.16[b]

Values are arithmetic means ± SD. Values in a row with different superscript letters are significantly different, $p \leq 0.05$. EALT-AC, erythrocyte alanine transaminase activity coefficient; EAST-AC, erythrocyte aspartate transaminase activity-coefficient.