J Community Nutrition 3(2) : 120~126, 2001 ☐Original Article☐

Nutritional Status of Antioxidant Vitamins in the Elderly Living in Ulsan Metropolitan City*

Jung Hee Kim,† Mi Joung Kim, Ok Hyun Kim

Division of Food and Nutrition, College of Natural Sciences, Seoul Women's University, Seoul, Korea

ABSTRACT

Body antioxidant status is an important factor for the prevention of many chronic diseases in the elderly. This study was done to evaluate the nutritional status of antioxidant vitamins of the elderly by determining their intakes and plasma levels. It was also aimed to compare daily intakes and plasma levels of antioxidant vitamins by sex and age. Subjects were 225 elderly persons aged over 60 years old (63 males, 162 females) living in Ulsan area. Subjects were divided by 6 groups according to age(< 65, 65 - 74, ≥ 75) and sex. Dietary Intakes were assessed by semi-quantitative food frequency questionnaires(FFQ). Plasma Vitamin C level was measured by 2,4-dinitrophenylhydrazine method and plasma levels of vitamin E, A and β-carotene were measured by HPLC. The average intakes of vitamin C were 104.9g(150% of RDA) and 104.4g(149% of RDA) in the elderly males and females, respectively. Vitamin C intake of the elderly was significantly decreased by aging but not different by sex. The average intakes of vitamin A were 678μgRE(96.9% of RDA) and 604μgRE(86.2% of RDA) in elderly males and females, respectively. The average levels of plasma vitamin C were 6.22mg/L and 11.45mg/L in the elderly males and females, respectively. Those levels are within normal range(6 - 20mg/L). However the percentage of the elderly males with deficiency(< 2mg/L) and marginal level(2 - 4mg/L) of vitamin C were 27.4% and 16.1%, respectively. Plasma retinol levels were 0.39mg/L for the elderly males and 0.37mg/L for the elderly females, which were within normal range. But the percentage of subjects with marginal level were 28% in both males and females. Plasma α-tocopherol levels of the elderly were lower than normal range(5 - 12mg/L). Plasma levels of vitamin C, E and β-carotene, except retinol, were significantly higher in the elderly females compared to males and showed a significant decrease by aging. (*J Community Nutrition* 3(2) : 120~126, 2001)

KEY WORDS : elderly · antioxidant vitamins · nutritional status.

Introduction

A lot of studies have shown that age-associated chronic diseases are related to free radicals and imbalance in antioxidant and oxidative stress(Enstrom et al. 1992 ; Gey & Puska 1989). Therefore body antioxidant capacity is an important factor for the prevention of many chronic diseases such as aging, cancer, cardiovascular disease and diabetes, especially in the elderly(Buring & Hennekens 1997 ; Goodman 1993 ; Kaneto et al. 1999).

Oxygen-derived free radical are the by products of aerobic metabolism. These reactive oxygen species are created through physiological and biochemical processes. Such a reactive oxygen species and other pro-oxdants are important mediators in signal transduction and play a vital role in the production of biological active compounds. However, they are toxic and known to inflict damage on cells by promoting the oxidation of lipids, proteins and DNA. Humans are also exposed to environmental sources of pro-oxidants such as cigarette smoking, ultraviolet radiation and oxidizing agents(Gutteridge 1994).

There are many natually occuring substances and antioxidants to protect against the potentially harmful effects of pro-oxidants. Vitamin E is the major lipid-soluble antioxidant in cell membranes. It protects against lipid peroxidation by acting directly with a variety of oxygen radicals, including singlet oxygen, lipid peroxide products and the superoxide radical, to form a relatively innocuous tocopherol radical(Clarkson & Thompson 2000 ; Packer 1991). Vitamin C is water soluble and can directly react with superoxide, hydroxy

*This study was supported by a grant of the Korea Health 21 R &D Project, Ministry of Health and Welfare, Republic of Korea (HMP-00-CH-17-0016).

†**Corresponding author** : Jung Hee Kim, Division of Food and Nutrition, College of Natural Sciences, Seoul Women's University 126 Kongnung 2-dong, Nowon-gu, Seoul 139-774, Korea
Tel : 02) 970-5646, Fax : 02) 970-5646
E-mail : jheekim@swu.ac.kr

radicals, and singlet oxygen in plasma(Frei et al. 1989). In addition, ascorbic acid has the ability to regenerate the activity of lipid-soluble antioxidants such as tocopherol and carotene(Jailal & Grundy 1991). β-carotene, the major carotenoid precursor of vitamin A, is the most efficient quencher of singlet oxygen(Krinsky 1993). It has been known that a combination of antioxidants is more effective than one individual antioxidant in isolation(Niki et al. 1995).

Vitamins C, A and E are the most abundant and effective antioxidants in human plasma and is believed to be of major importance in the protection against diseases and degenerative processes caused by oxidative stress. Epidemiological studies have demonstrated an association between increased intake of antioxidant vitamins such as vitamin E and vitamin C and reduced morbidity and mortality from coronary artery disease(Diaz et al. 1997 ; Michael 1995). Case-control studies indicated that patients with angina pectoris have lower plasma concentrations of vitamin E than normal subjects(Riemersma et al. 1991). Prospective cohort studies have also found an inverse association between the frequency of coronary artery disease and dietary intake of antioxidant vitamins(Enstrom et al. 1992 ; Khaw et al. 2001). Therefore, the potential of dietary antioxidants to reduce the risk of coronary vascular disease is gaining a great deal of interest in the medical and scientific community.

Although recently the population of the elderly is continuously increasing, there is few report about antioxidant status of the elderly or their relationship to between age-related diseases and antioxidant status in Korea. The objectives of this study were to investigate nutritional status of antioxidant vitamins by determining plasma levels of vitamin A, C, E and β-carotene and their intakes of the elderly living in Ulsan metropolitan city.

Subjects and Methods

1. Subjects

Subjects were 225 elderly people aged over 60 years, recruited at 2 public health centers in Ulsan area. Males were 63 persons and females were 162 persons. Subjects were divided by 6 groups according to age(< 65, $65-74$, ≥ 75) and sex. Height and weight were measured and blood samples were obtained.

2. Dietary assessment

Dietary data were obtained through questionnaires by interviewers trained for nutritional survey. Dietary intakes were assessed by semi-quantitative food frequency questionnaires(FFQ) that included 98 commonly consumed food items selected from Korean National Health and Nutrition Survey for elderly population('98 KNHANS 1999). Nutrient intakes were analyzed by computer program developed in our research team.

3. Analysis of plasma antioxidant vitamins

Vitamin C was assayed from plasma sample pretreated with 0.75M meta-phosphoric acid by 2, 4-dinitrophenylhydrazine method using an UV spectrophotometer(Pesce & Kaplan 1987).

Vitamin A and E were assessed by measuring retinol and α-tocopherol, repectively. Plasma vitamin A and E were extracted with ethyl alcohol and hexane. Retinol and α-tocopherol were separated by HPLC on Nova-Pak C_{18}(3.9 × 150mm) column using methanol-water (95 : 5, v/v) as the mobile phase. Elution was detected spectrophotometrically at 292nm(Bieri et al. 1979).

Plasma β-carotene were extracted with alsolute alcohol : distilled water : hexane(1 : 1 : 2) and separated by HPLC on Nova-Pak C_{18}(3.9 × 150mm) column using acetonitrile : dichrolomethane : methanol(7 : 2 : 1) as mobile phase. Elution was detected spectrophotometrically at 452nm(Bieri et al. 1985).

4. Statistical analysis

All data were expressed as mean ± SD. Statistical analysis was performed by SAS-PC program. Statistically significant difference was determined by using ANOVA, Student's t-test and Duncan's multiple range test. The relationship between intakes and plasma levels of antioxidant vitamins was analyzed by Pearson's correlation test.

Results and Discussion

1. Age and sex distribution of subjects

Subjects were 225 elderly people aged over 60 years, living in Ulsan area.

Males were 63 persons and females were 162 persons. The mean ages of both males and females were 71.4. Subjects were divided by 6 groups according to age(< 65, 65 – 74, ≥ 75) and sex. The percentage of males was 28% and that of females was 72%. About 63% of subjects was the elderly aged 65 – 74 and about 26% of them was the elderly aged over 75 years old. About 11% of subjects was the elderly aged 60 – 64 years old.

2. Dietary intakes of antioxidant vitamins in the elderly

The average intakes of vitamin C were 104.7mg/day and 104.4mg/day in the elderly males and females, respectively(Table 2). Vitamin C intake of the elderly was significantly decreased by aging. Particularly vitamin C intake of the elderly females aged over 75 years old was the lowest among the groups. But there was no significant difference in the vitamin C intakes between the elderly males and females. When the vitamin C intakes were compared to Korean RDA, average vitamin C intakes of both the elderly males and females were about 150% of RDA. But the percentage of subjects consumed less than 75% of Korean RDA (2000) were 29.3% and 31.2% in the elderly males and females, respectively(Table 3).

According the 1998 National Health and Nutrition Survey('98NHANS), average intakes of vitamin C of the elderly aged over 65 years old were 98.2mg/day for males and 90.6 mg/day for females(Ministry of Health and Welfare 1999). But results of a seasonal nutrition survey showed that the elderly males and females consumed 71.5mg/day and 67.7mg/day through a year, respectively(Ministry of Health and Welfare 2000). In another study(Oh & Hong 2000), the daily intake of vitamin C in the elderly living Incheon metropolitan city was 124.8mg/day. Such a difference in vitamin C intake among studies might be mainly due to dietary assessment methods. This and other studies used semi-quantitative FFQ method while '98NHANS used 24 hour recall method. In addition to method, since vitamin C intake has a seasonal variation, it depend on season examined and living area of the subjects, and so on.

In this study, the average intakes of vitamin A were 678μgRE(96.9% of RDA) and 604μgRE(86.2% of RDA) in elderly males and females, respectively(Table 2). The percentage of subjects consumed less than 75% of Korean RDA were 48.3% and 59.8% in elderly males and females, respectively(Table 3). Vitamin A intake of the

Table 1. Distribution of the elderly by age and sex

	Males	Females	Total
Age			
60 – 64	5[1](8.0)	20(12.3)	25(11.1)
65 – 74	41 (65.1)	100(61.7)	141(62.7)
≥ 75	17 (27.0)	42(25.9)	59(26.2)
Total	63 (28.0)	162(72.0)	225(100)

1) Number of subjects
( ) : % of subjects

Table 2. Comparison of antioxidant vitamin intakes in the elderly by age and sex

		60 – 64	65 – 74	≥ 75	Total
Vit. C(mg)	Male	271.7 ± 373.0[1]^{a}	94.3 ± 62.6^{bc}	88.2 ± 51.1^{c}	104.7 ± 112.5
	Female	163.2 ± 143.2^{b}	109.0 ± 82.8^{bc}	64.8 ± 57.9^{c}	104.4 ± 91.7
	Total	181.3 ± 191.3^{x}	104.8 ± 77.7^{y}	71.4 ± 56.6^{y}	
Vit. A(μgRE)	Male	993 ± 1070^{a}	680 ± 495^{ab}	594 ± 381^{ab}	678 ± 516
	Female	765 ± 544^{ab}	671 ± 521^{ab}	366 ± 270^{b}	604 ± 491
	Total	803 ± 634^{x}	674 ± 512^{x}	403 ± 319^{y}	
Retinol(μg)	Male	63.2 ± 58.7^{ab}	56.2 ± 47.3^{ab}	80.1 ± 52.5^{a}	63.3 ± 49.7*
	Female	58.3 ± 58.3^{ab}	51.4 ± 41.3^{ab}	38.0 ± 45.8^{b}	48.8 ± 45.1
	Total	59.1 ± 57.1^{NS}	52.8 ± 43.0	49.8 ± 51.0	
β-carotene(μg)	Male	5349 ± 6051^{a}	3537 ± 2729^{ab}	2936 ± 1959^{b}	3496 ± 2846
	Female	3823 ± 2842^{ab}	3452 ± 2809^{ab}	1842 ± 1476^{b}	3078 ± 2628
	Total	4077 ± 3432^{x}	3476 ± 2776^{x}	2149 ± 1682^{y}	

1) Mean ± SD, * : $p < 0.05$ between males and females by t-test, NS : not-significantly different
ab : means with different superscript letter are significantly different among groups at $p < 0.05$ by Duncan's multiple range test
xy : means with different superscript letter are significantly different among different age groups at $p < 0.05$ by Duncan's multiple range test

elderly was also significantly decreased by aging but not different by sex. Overall vitamin A intakes were poor in all groups. Particularly 73.2% of the elderly females aged over 75 years old consumed vitamin A below 75% of RDA. Retinol intakes were not significantly changed by aging but there was significantly differences between males and females. Similar to vitamin C intakes, both intakes of retinol and β-carotene were lowest in the elderly females aged over 75 years old.

'98NHANS showed that average intakes of vitamin A of the elderly aged over 65 years old were 430.2μgRE/day for males and 379.9μgRE/day for females(Ministry of Health and Welfare 1999). But results of a seasonal nutrition survey showed that the elderly males and females consumed 485.9μgRE/day and 441.1μgRE/day through a year, respectively(Ministry of Health and Wellfare 2000). A study(Oh & Hong 2000) showed 404.2μgRE/day of vitamin A intake in the elderly living Incheon metropolitan city. Another study(Park et al. 2001) showed that vitamin A intakes of the elderly living in rural area were 522μgRE/day in males and 325μgRE/day in females. Vitamin A intake of the elderly living in Ulsan metropolitan city was greater than that of the elderly living in the other areas. It might be associated with difference of dietary assessment methods and/or higher income of Ulsan area.

3. Plasma levels of antioxidant vitamins in the elderly

Plasma levels of antioxidant vitamins are presented in Table 4. The average levels of plasma vitamin C were 6.22mg/L and 11.45mg/L in the elderly males and females, respectively. Plasma vitamin C level of the elderly females was significantly higher than that of the elderly males. Such lower levels of plasma vitamin C in the elderly males seem to be associated with health related behavior such as smoking, drinking and exercise status. But there was no significant difference in plasma vitamin C level by aging.

Table 3. Percentage of antioxidant vitamin intakes for Korean RDA in the elderly

		60 - 64	65 - 74	≥ 75	Total
Vit. C(RDA : 70g)	Male	388.1[1)](0)	134.7(34.2)	126.0(25)	149.6(29.3)
	Female	233.1(20.0)	155.7(26.1)	92.6(46.3)	149.1(31.2)
	Total	259.0	149.7	102.0	
Vit. A(RDA : 700μgRE)	Male	141.9(45)	97.1(47.4)	84.9(43.8)	96.9(48.3)
	Female	109.3(50)	95.9(55.2)	52.3(73.2)	86.2(59.8)
	Total	114.7	96.2	61.5	

1) % of KRDA(7th revision, 2000), ( ) : % of subjects consumed below 75% KRDA

Table 4. Comparison of plasma antioxidant vitamin levels in the elderly by age and sex

		60 - 64	65 - 74	≥75	Total
Vit. C(mg/L)	Male	5.90 ± 4.48[1)b]	6.34 ± 4.31[b]	6.04 ± 5.96[b]	6.22 ± 4.75***
	Female	12.42 ± 4.42[a]	11.72 ± 4.69[a]	10.38 ± 5.90[a]	11.45 ± 5.01
	Total	11.11 ± 5.09[x]	10.13 ± 5.18[x]	9.11 ± 6.20[x]	
Vit. E(mg/L)	Male	3.12 ± 1.15[b]	2.96 ± 0.70[b]	2.94 ± 0.98[b]	2.97 ± 0.81***
	Female	4.60 ± 2.63[a]	3.81 ± 1.37[ab]	3.47 ± 1.30[b]	3.82 ± 1.59
	Total	4.30 ± 2.46[x]	3.56 ± 1.27[y]	3.32 ± 1.23[y]	
Vit. A(mg/L)	Male	0.43 ± 0.12[NS]	0.39 ± 0.15	0.38 ± 0.09	0.39 ± 0.14
	Female	0.36 ± 0.08	0.38 ± 0.10	0.36 ± 0.15	0.37 ± 0.11
	Total	0.37 ± 0.09[x]	0.38 ± 0.12[x]	0.36 ± 0.13[x]	
β-carotene(mg/L)	Male	1.50 ± 1.10[cd]	1.72 ± 1.20[bcd]	1.12 ± 1.10[d]	1.52 ± 1.20***
	Female	3.51 ± 1.62[a]	2.91 ± 1.71[ab]	2.53 ± 2.20[abc]	2.92 ± 1.90
	Total	3.02 ± 1.70[x]	2.62 ± 1.72[xy]	2.10 ± 2.00[y]	

1) Mean ± SD, *** : $p < 0.001$, between males and females by t-test
ab : means with different superscript letter are significantly different among groups at $p < 0.05$ by Duncan's multiple range test
xy : means with different superscript letter are significantly different among different age groups at $p < 0.05$ by Duncan's multiple range test

The range of plasma vitamin C level seen in persons on normal diet is from 6 to 20mg/L. Criteria from the Nutrition Canada Survey were used to classify the risk of clinical surveys. Respondents with serum vitamin C levels of 2mg/L or less were considered to be at a high risk for clinical vitamin C deficiency while those with serum levels of 2 – 4mg/L were considered to be at a marginal risk(Schectman et al. 1989). Of all subjects, 27.4% of the elderly males and 7.6% of the elderly females had plasma levels of 2mg/L or less. The percentage of the elderly with marginal levels(2 – 4mg/L) of vitamin C were 16.1% and 1.3% for males and females, respectively(Table 5). Therefore the vitamin C status of males was not so good compared to that of females. It has been known that smoking increases the risk of hypovitaminosis C. Kallner et al. (1981) measured vitamin C kinetics using radio-labeled ascorbic acid and demonstrated an increased turnover of vitamin C in smokers, but only small differences in absorption when compared to non-smokers. In this study, such a lower plasma level of vitamin C in males compared to females seemed to be related to higher smoking rates in males.

The nutritional status of vitamin A can be assessed by the measurement of plasma retinol. Plasma retinol levels were 0.39mg/L and 0.37mg/L for the elderly males and females, respectively(Table 4). The plasma retinol levels showed no significant differences between males and females and did not change by aging. The average plasma retinol levels of the elderly were within normal range, 0.32 – 0.90mg/L(Pesce & Kaplan 1987). Signs of vitamin A deficiency are usually seen at plasma retinol levels less than 0.1mg/L, while those with plasma levels between 0.1 and 0.3mg/L were considered to be at a marginal risk(Wahed et al. 1995). Of all subjects, none had plasma levels of deficiency.

Table 5. Distribution of subjects according to nutritional status of antioxidant vitamins

		Deficiency	Marginal	Normal
		< 2	2 – 4	> 4
Vit. C (mg/L)	Male	17[1](27.4)	10(16.1)	35(56.5)
	Female	12 (7.6)	2(1.3)	143(91.1)
		< 0.1	0.1 – 0.3	> 0.3
Vit. A (mg/L)	Male		17(28.3)	43(71.7)
	Female		44(28.2)	112(71.8)

1) Number of subjects, ( ) : % of sujects

But the percentages of subjects with marginal levels were about 28.3% and 28.2% in males and females, respectively(Table 5). In contrast to retinol level, plasma β-carotene levels were significantly lower in the elderly males than females and significantly deceased by aging.

Plasma α-tocopherol level, 2.97mg/L of the elderly males was significantly lower than that, 3.82mg/L of the elderly females. Those levels were significantly decreased by aging. But overall plasma levels of α-tocopherol of the elderly were lower than normal range (5 – 12mg/L). In fact, vitamin E is absorbed in conjunction with fatty acids and TG and its distribution follows that of TG or other lipids via lipoproteins. Thus plasma α-tocopherol level is dependent on the plasma lipid contents. Plasma α-tocopherol level itself might not be a good indicator for vitamin status.

To adjust the difference of dietary intake of vitamin A and C, their ratio of plasma levels per intakes were calculated(Table 6). The ratio of plasma vitamin C level per intake was significantly higher($p < 0.001$) in the elderly females than in the elderly males. Similar to vitamin C, the ratio of plasma vitamin A per intake was also significantly higher in the elderly females compared to males.

Particularly the ratios of plasma vitamin C and A levels per their intakes were the highest in the elderly females aged over 75 years old.

Correlation data is shown in Table 7. There was no significant positive correlation between vitamin C intake and its plasma levels. Plasma vitamin C levels can be influenced by age, sex, smoking, BMI, socio-economic status, vitamin supplementation and medication, etc(Ausman 1999 ; Carr & Frei 1999 ; Park et al. 1998). If one can exclude effects of these various potentially confounding factors, vitamin C intake might be positively correlated with its plasma level. Particularly plasma vitamin C level was significantly decreased by cigarette smoking(Kim & Moon 1997 ; Hornig & Glatthaar 1985). The elderly males and females examined in this study showed similar patterns although the data is not shown here.

There was a positive correlation between vitamin C intake and plasma β-carotene level. In addition, plasma retinol level was positively correlated with its intake.

Table 6. Comparison of plasma level/intake ratio for antioxidant vitamins in the elderly by age and sex

Ratio \ Age		60 - 64	65 - 74	≥ 75	Total
Vit. C plasma level/intake	Male	33.7 ± 35.4[1)b]	86.2 ± 82.2[b]	89.8 ± 119.9[b]	83.5 ± 92.0***
	Female	129.8 ± 92.2[b]	172.9 ± 160.2[ab]	452.9 ± 879.0[a]	240.5 ± 480.8
	Total	113.8 ± 92.3[y]	148.2 ± 147.4[x]	371.7 ± 802.9[x]	
Vit. A plasma level/intake	Male	0.75 ± 0.50[b]	0.79 ± 0.50[b]	0.93 ± 0.60[b]	0.83 ± 0.53**
	Female	0.72 ± 0.51[b]	0.99 ± 0.78[b]	2.19 ± 2.68[a]	1.27 ± 1.60
	Total	0.73 ± 0.50[y]	0.94 ± 0.72[y]	1.96 ± 2.49[x]	

1) Mean ± SD, **, *** : $p < 0.01$, $p < 0.001$ between males and females by t-test
abc : means with different superscript letter are significantly different among groups at $p < 0.05$ by Duncan's multiple range test
xy : means with different superscript letter are significantly different among different age groups at $p < 0.05$ by Duncan's multiple range test

Table 7. Correlation coefficient between antioxidant vitamin intakes and/among plasma antioxidant indices

\plasma level		Vit. C	Vit. E	Vit. A	β-carotene
Intake	Vit. C	0.130	-0.043	0.002	0.144*
	Vit. A	0.070	-0.101	0.040	0.125
	β-carotene	0.074	-0.094	0.025	0.107
	Retinol	0.054	-0.064	0.179*	
Plasma level	Vit. C				
	Vit. E	0.402***			
	Vit. A	0.031	0.342***		
	β-carotene	0.356***	0.176*	0.082	

* : $p < 0.05$, *** : $p < 0.001$

There were significant positive correlations($p < 0.001$) between plasma C and lipid soluble antioxidants, vitamin E and β-carotene. These data might suggest that Vitamin C regenerates lipid soluble antioxidants, thereby saving them. Plasma vitamin E level was also positively correlated with vitamin A and -βcarotene levels. Since they are all lipid soluble vitamins, their plasma levels could be related to plasma lipid levels.

Summary and Conclusions

The purpose of this study was to evaluate the nutritional status of the elderly by determining intakes and plasma levels of antioxidant vitamins(vitamin C, A, E, β-carotene). Subjects were 225 elderly persons(63 males, 162 females)living in Ulsan area. Subjects were divided by 6 groups according to age(< 65, 65 - 74, > 75). The results of this study are summarized as follows :

1) The average intakes of vitamin C were 104.9mg (150% of RDA) and 104.4mg(149% of RDA) in the elderly males and females, respectively. Vitamin C intake of the elderly was significantly decreased by aging but not different by sex.

2) The average intakes of vitamin A were 678μgRE (96.9% of RDA) and 604μgRE(86.2% of RDA) in elderly males and females, respectively. Vitamin A intake of the elderly was also significantly decreased by aging but not different by sex.

3) The average levels of plasma vitamin C were 6.22mg/L and 11.45mg/L in the elderly males and females, respectively, which are within normal range(6 - 20mg/L). The percentages of the elderly males with deficiency(< 2mg/L) and marginal level(2 - 4mg/L) of vitamin C were 27.4% and 16.1%, respectively.

4) Plasma retinol levels were 0.39mg/L for the elderly males and 0.37mg/L for the elderly females, which were within normal range. But the percentage of subjects with marginal levels was 28% in both males and females.

5) Plasma α-tocopherol level of the elderly were 2.97mg/L for males and 3.82mg/L for females, which were a little lower than normal range(5 - 12mg/L).

6) Plasma levels of vitamin C, E and β-carotene, except retinol, were significantly higher in the elderly females and showed a significant decrease by aging. Therefore the elderly males aged over 75 years old had the lowest plasma levels of antioxidant vitamins although they consumed more antioxidant vitamins compared to females.

7) Correlation data showed that vitamin C intake was positively correlated with plasma β-carotene level. In addition, plasma vitamin C level was positively correlated with plasma lipid-soluble abtioxidant vitamins, vitamin E and β-carotene.

Overall data suggest that plasma levels of antioxidant vitamins except retinol were higher in the elderly females compared to males although there were no sig-

nificant differences in their overall intakes by sex. Such lower levels of plasma antioxidant vitamins in the elderly males might be associated with health-related behavior such as smoking, drinking and exercise status.

References

Ausman LM(1999) : Criteria and recommendations for vitamin C intake. *Nutr Rev* 57(7) : 222-224

Bieri JG, Brown ED, Smith JC(1985) : Determination of individual carotenoid in human plasma by high performance liquid chromatography. *J Liq Chrom* 8(3) : 474-484

Bieri JG, Tolliver TJ, Catignani GL(1979) : Simultaneous determination of α-tocopherol and retinol in plasma or red cells by high pressure liquid chromatography. *Am J Clin Nutr* 32 : 2143-2149

Buring JE, Hennekens CH(1997) : Antioxidant vitamins and cardiovascular disease. *Nutr Rev* 55 : S53-S60

Carr AC, Frei B(1999) : Toward a new recommended dietary allowance for vitamin C based on antioxidant and health effects in humans. *Am J Clin Nutr* 69(6) : 1086-1097

Clarkson PM, Thompson HS(2000) : Antioxidants : What role do they play in physical activity and health. *Am J Clin Nutr* 72 : 637S-646S

Diaz MN, Frei B, Vita JA, Keaney JF(1997) : Antioxidants and atherosclerotic heart disease. *New Engl J Med* 337 : 408-416

Enstrom JE, Kanim LE, Klein MA(1992) : Vitamin C intake and mortality among a sample of the United States population. *Epidemiology* 3 : 194-202

Frei B, England L, Ames BN(1989) : Ascorbate is an outstanding antioxidant in human blood plasma. *Proc Natl Acad Sci* 86 : 6377-6381

Gey KF, Puska P(1989) : Plasma vitamin E and A inversely correlated to mortality from ischemic heart disease in cross-culture epidemiology. *Ann NY Acad Sci* 570 : 268-3001

Goodman DS(1984) : Vitamin A and retinoids in health and disease. *New Engl J Med* 310 : 1023-1031

Gutteridge JM(1994) : Biological orgin of free radicals and mechanisms of antioxidant protection. *Chemico-Biological Interaction* 91 : 133-140

Hornig DH, Glatthaar BE(1985) : Vitamin C and smoking : Increased requirements of smokers. *In J Vit Nutr Res* 27(s) : 139-155

Jailal I, Grundy SM(1991) : Preservation of the endogenous antioxidant in low density lipoprotein by ascorbate but not probucol during oxidative modification. *J Clin Invest* 87 : 597-601

Kallner AB, Hartmann D, Homig DH(1981) : On the requirements of ascorbic acid in man : Steady state turnover and body pool in smokers. *Am J Clin Nutr* 34 : 1347-1355

Kaneto H, Kajimoto Y, Miyagawa J, Matsuoka T, Fujitani Y, Umayahara Y, Hanafusa T, Matsuzawa Y, Yamasaki Y, Hori M(1999) : Beneficial effects of antioxidants in daibetes. *Diabetes* 48 : 2398-2406

Khaw KT, Bingham S, Welch A, Luben R, Wareham N, Oakes S, Day N(2001) : Relation between plasma ascorbic acid and mortality in men and women in EPIC-Norfolk prospective study : a prospective population study. European prospective investigation into cancer and nutrition. *Lancet* 357 : 657-663

Kim JH, Moon JS(1997) : A study on dietary intakes and nutritional status in college women smokers. *Korean J Commun Nutr* 2(2) : 159-168

Kim JH, Lim JY, Kim KW(1998) : Assessment of nutritional status and factors related to smoking in adolescent male smokers. *Korean J Commun Nutr* 3(3) : 349-357

Korean Nutrition Society(2000) : Korean Dietary Recommened Allowances. 7th revision.

Krinsky NI(1993) : Actions of carotenoids in biological systems. *Ann Review Nutr* 13 : 561-567

Michael FO(1995) : Antioxidant nutrients atherosclerosis and coronary heart disease. *Brit Heart J* 73 : 275-280

Ministry of Health and Welfare(1999) : 1998 national health and nutrition survey - Nutrition Survey -

Ministry of Health and Welfare(2000) : In-depth analysis on 1998 national health and nutrition survey - Nutrition Survey -

Niki E, Noguchi N, Tsuchihashi H, Gotoh N(1995) : Interaction among vitamine C, vitamine E, and β-carotene. *Am J Clin Nutr* 62 : 1322S-1326S

Oh SY, Hong MH(2000) : Development of a simple food frequency questionnaire using the contribution of specific foods to absolute intake and between person variation of nutrient consumption for the Korean elderly. *Korean J Nutr* 33(4) : 429-437

Packer L(1991) : Protective role of vitamine E in biological systems. *Am J Clin Nutr* 53 : 1050S-1055S

Park S, Yu JG, Lee JY(1998) : Analysis of factors to influence requirements of vitamin E and vitamin C in young and healthy men and women. *Korean J Nutr* 31(4) : 729-738

Park MY, Lee KH, Youn HS(2001) : Nutrition status of the rural elderly living in Kyungnam. *Korean J Commun Nutr* 6 (3S) : 527-541

Pesce AJ, Kaplan LA(1987) : Methods in clinical chemistry. The CV Mosby-Company, St. Louis Washington DC, Toronto. Part 10, Chapter 75 : 574-581

Riemersma RA, Wood DA, Macintyre CCH, Elton RA, Gey KF Oliver MF(1991) : Risk of angina pectoris and plasma concentrations of vitamin A, C, E and carotene. *Lancet* 337 : 1-5

Schectman G, Byrd JC, Gruchow HW(1989) : The influence of smoking on vitamin C status in adults. *Am J Pub Health* 79(2) : 158-162

Wahed MA, Alvarez JO, Khaled MA, Rahman CM, Habte D(1995) : Comparison of the modified relative dose response and the relative dose response in the assessment of vitamin A status in malnourished children. *Am J Clin Nutr* 61 : 1253-1256