

RELATIONSHIP BETWEEN SERUM ANTIOXIDANT VITAMINS A, E, AND C AND LIPID PROFILES IN PRIEST SUBJECTS AT THE PRIEST HOSPITAL

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Abstract. The serum vitamins A, E, and C (antioxidant vitamins) of 112 priest subjects, compared with 90 males and 119 females in a control group, were investigated. Subjects for the study were Thai volunteers who attended the Outpatient Department, Priest Hospital, Bangkok, for a physical check-up from July to September 2003. There was no age difference between the priest group and the controls. All serum vitamins, A, E, and C, of the priest group were significantly lower than the control group. Statistically significantly higher levels of total cholesterol, LDL-C, and LDL-C/HDL-C ratio were found in the priest subjects compared with the controls. The median serum retinol concentration in the priest subjects was 3.02 $\mu\text{mol/l}$ (range 1.47-4.01 $\mu\text{mol/l}$) compared with 3.23 $\mu\text{mol/l}$ (range 1.74-4.57 $\mu\text{mol/l}$) in the controls ($p < 0.01$). The median serum α -tocopherol concentration in the priest subjects was 18.1 mmol/l (range 5.8-27.3 $\mu\text{mol/l}$) compared with 19.6 mmol/l (range 7.3-37.7 $\mu\text{mol/l}$) in the controls ($p < 0.01$). The median serum ascorbic acid concentration in the priest subjects was 3.74 mg/l (range 0.0-17.0 mg/l) compared with 6.37 mg/l (range 0.0-18.0 mg/l) in the controls. The median values for retinol, α -tocopherol, and ascorbic acid serum concentrations in the male priests were lower than the control males. A total of 28% and 65% of the priest subjects had decreased α -tocopherol and ascorbic acid levels, while the controls had decreased α -tocopherol and ascorbic acid levels of 20% and 31.5%, respectively. A total of 67.8% and 54.4% of priest and control subjects, respectively, had cholesterol concentrations of ≥ 5.18 mmol/l. However, a prevalence of low HDL-C (HDL-C ≤ 0.91 $\mu\text{mol/l}$) was found in 1.8% of priest subjects and 1.4% of controls. Statistically significant associations were found between α -tocopherol, cholesterol, LDL-C, triglyceride, and serum retinol. A positive correlation was found between age, retinol, and serum α -tocopherol. A negative correlation was found between cholesterol, HDL-C, LDL-C, and the serum α -tocopherol/cholesterol ratio. In addition, negative correlations were found between weight, cholesterol, LDL-C, triglyceride, and the serum α -tocopherol/(cholesterol+ triglyceride) ratio in priest and control subjects. The results suggest more research should be conducted into the health and nutritional problems of both healthy and diseased priest subjects concerning vitamins and oxidative stress.

INTRODUCTION

Epidemiological research has clearly shown large differences in mortality rates across Europe (Chambless *et al*, 1989; James *et al*, 1989; Tunstall-Pedoe *et al*, 1999); that high intake of fruits and vegetables (such as in a 'Mediterranean-type diet') or high levels of their biomarkers (vitamins C, E, and carotenoids) are associated with a relatively low incidence of cardiovascular disease (Armstrong *et al*, 1975; Acheson and Williams, 1983; Gey *et al*, 1993; Knekt *et al*, 1994; Morris *et al*, 1994), cataract (Jacques *et al*, 1988; Knekt *et al*, 1992; Seddon *et al*, 1994;

Mares-Perlman *et al*, 1995), and cancer (Wald *et al*, 1988; Batieha *et al*, 1993; Giovannucci *et al*, 1995; Zheng *et al*, 1995; WCRF and AICR, 1997).

Several biological activities have been described for these compounds (Sies *et al*, 1992; Azzi *et al*, 1995; Bertram *et al*, 1995), although the most currently studied mechanism for this preventive effect is their antioxidant capacity. This infers that exposure to a high fruit and vegetable diet increases antioxidant concentrations in blood and body tissues, in particular vitamins C, and E, and carotenoids, which are capable of protecting against oxidative damage to cells and tissues. Vitamin C is a well-established, water-soluble antioxidant whose intake is positively related with that of fruit and vegetables, which are also major contributors to carotenoid intake. The α -tocopherol (a major antioxidant in the lipid phase) intake is associated with the predominantly used seed oil; although it is not so readily associated with fruit and

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vegetable intake, it is generally assumed that a high fruit and vegetable diet ('Mediterranean-type diet') is also associated with increased intake (James *et al*, 1989; Bellizi *et al*, 1994).

Dietary intake and serum concentrations of carotenoids show a great variability among populations (Granado *et al*, 1996; Olmedilla *et al*, 1997) and several factors influence serum carotenoid concentrations and, to a lesser extent, the concentrations of α -tocopherol and retinol (Nierenberg *et al*, 1989; Hercberg *et al*, 1994; Olmedilla *et al*, 1994). This fact complicates the comparability and the interpretation of serum carotenoid levels between different populations.

LDL is therefore not only rich in cholesterol but also in polyunsaturated fatty acids, known to be highly susceptible to lipid peroxidation, which are protected by the presence of several antioxidants. In particular, vitamins E, C, and A, and carotenoids are capable of protecting against oxidative damage to cells and tissue. The major antioxidant is α -tocopherol; on average about seven molecules of this antioxidant are present in each LDL particle. Other potential antioxidants in LDL are γ -tocopherol, β -carotene, α -carotene, lycopene, cryptoxanthin, canthaxanthin, lutein, zeaxanthin, phytofluene, retinoids, and ubiquinol-10. However, these are present in amounts 20-300 times lower than α -tocopherol.

Comparison of dietary intake data, that is, total amounts consumed, provides little useful information about the amounts actually absorbed. The absorption and metabolism of lipid-soluble antioxidants is complex, still poorly understood, and markedly influenced by food structure and host nutritional status (Parker, 1997; Castenmiller and West, 1998). In addition, particularly for carotenoids, the comparison of results for blood and tissue analysis arising from different laboratories is still difficult because of large inter-laboratory variation (van den Berg *et al*, 1993).

Priests, or Buddhist monk, subjects are at particular risk for low nutrient intakes, often due to the following: reduced energy consumption related to a decrease in activity level, less access to foods (only 2 meals per day) with adequate nutritional content, and chronic diseases. The aim of this study was to examine the associations between antioxidant vitamins, retinol, α -tocopherol, and vitamin C; and lipid profiles in Buddhist monks.

MATERIALS AND METHODS

Study population

The study population was comprised of 112 priest

subjects (healthy = 33, diabetes mellitus + complications = 39, dyslipidemia + complications = 22, heart disease + complications = 18.), and a control group of 209 subjects (90 males and 119 females). Subjects for the study were Thai volunteers who attended the Outpatient Department, Priest Hospital, Bangkok, for a physical check-up from July to September 2003. Informed consent was obtained from the subjects before blood specimens were drawn. The age, marital status, place of origin, and drinking and smoking habits were assessed through standardized questionnaires. The same medical doctor conducted physical examinations throughout the study. Approval was obtained from the Ethics Committee and all participants gave written informed consent.

Analytical methods

The body weight of each individual dressed in light clothing was measured using a carefully calibrated beam balance (Detecto®). Fasting venous blood samples were taken from all volunteers into plain blood tubes having no anticoagulant, and serum samples were separated and stored at 2-5°C for not more than 24 hours prior to lipid profile and vitamin C determination. A serum aliquot was stored frozen at -70°C for serum retinol and α -tocopherol then analyzed within 1 month of collection to ensure the stability of the compounds.

Laboratory techniques

A commercially available, Boehringer Mannheim (Germany), test kit was used to determine cholesterol, high density lipoprotein-cholesterol (HDL-C), low density lipoprotein-cholesterol (LDL-C), and triglycerides (TG). The values of ≥ 5.18 mmol/l and 6.48 mmol/l of cholesterol, ≥ 3.98 mmol/l of LDL-C, ≤ 0.91 mmol/l of HDL-C, and ≥ 2.26 mmol/l of TG were taken as cut-off points. All trans-retinol, retinyl acetate, and α -tocopherol standards were obtained from Sigma Chemical Company (St Louis, MO, USA). Methanol, ethanol, and hexane were obtained from Merck (Spain). Serum retinol and α -tocopherol were extracted and determined by using a reverse phase high performance liquid chromatography (HPLC) apparatus. HPLC analysis was carried out as described elsewhere (Abe and Katsui, 1975; Nilsson *et al*, 1978; De Leenheer *et al*, 1978; Maiani *et al*, 1993). Briefly, the chromatographic system consisted of an Aphasil column (250 \times 4.6mm). The mobile phase was methanol:water, 95:5 (by volume). Detection of compounds was carried out using a UV detector (Model 486, Waters Associates, Melford, MA, USA) set at 290 nm. Under these conditions, the following compounds could be resolved: retinol, retinyl acetate (internal standard), and α -tocopherol. Serum vitamin

C was determined according to the method described by Liu *et al* (1982). Values below 5 µg/l indicated a deficiency of vitamin C.

Statistical analysis

Standard statistical methods provided by the Minitab computer program were used to analyze the data (Ryan *et al*, 1985). Median, range and 95% confidence interval (CI) were calculated. The Mann-Whitney *U*-Wilcoxon Rank Sum *W* test (two tailed) was used to calculate statistical differences between groups.

RESULTS

The median, range, and 95% confidence interval

(CI) for age, weight, serum retinol, α -tocopherol, ascorbic acid concentration, and lipid profiles in priest and control subjects are shown in Table 1. No statistically significant differences from the controls were observed in age, weight, and triglyceride. Statistically higher levels of cholesterol, LDL-C, and LDL-C/HDL-C ratio were found in the priest subjects compared with the control subjects; whereas HDL-C, serum ascorbic acid, retinol, α -tocopherol, α -tocopherol/cholesterol, and α -tocopherol/cholesterol+TG were lower in the priest subjects. There were similar results for age, α -tocopherol, ascorbic acid concentration, and lipid profiles among the male priests compared with the male control subjects. However, there was no statistically significant difference in retinol between the male priests and the male control subjects. No

Table 1
Median, range and 95% CI of age, weight, lipid profiles, serum ascorbic acid, retinol, and α -tocopherol in male priest and male control subjects.

Parameter	Total (N=321)				p-value ^a	Male (N=202)				p-value ^a
	Priest (N=112)		Control (N=209)			Priest (N=112)		Control (N=90)		
	Median (range)	95%CI	Median (range)	95%CI		Median (range)	95%CI	Median (range)	95%CI	
Age (yr)	49 (21-70)	44-54	47 (23-68)	42-52	0.060	49 (21-70)	44-54	47 (24-68)	37.5- 56.0	0.369
Weight (kg)	64.5 (36-96)	62.5- 66.6	63.4 (44-96)	59.4- 67.4	0.500	64.5 (36-96)	62.5- 66.6	70.0 (63-96)	66.5- 76.7	0.048
Cholesterol (mmol/l)	6.0 (2.5-10.5)	5.75- 6.24	5.2 (3.1-8.9)	5.14- 5.38	0.000	6.0 (2.5-10.5)	5.14- 5.38	5.7 (3.6-7.2)	5.64- 5.88	0.000
HDL-C (mmol/l)	1.6 (0.8-2.7)	1.55- 1.69	1.7 (0.8-3.1)	1.60- 1.90	0.002	1.6 (0.8-2.7)	1.55- 1.69	1.9 (0.9-4.1)	1.7- 2.1	0.000
LDL-C (mmol/l)	3.8 (0.8-7.5)	3.58- 4.01	3.2 (0.9-6.3)	3.0- 3.4	0.000	3.75 (0.83-7.55)	3.58- 4.01	3.3 (1.7-5.2)	3.0- 3.5	0.000
LDL-C/ HDL-C	2.4 (0.6-2.4)	2.3- 2.5	2.1 (1.1-4.0)	2.0- 2.2	0.012	2.4 (0.6-4.3)	2.3- 2.5	2.36 (1.1-4.0)	2.3- 2.5	0.796
TG (mmol/l)	1.3 (0.4-6.8)	1.1- 1.5	1.1 (0.2-8.2)	2.2- 2.6	0.227	2.53 (0.8-15.6)	2.3- 2.8	2.48 (0.8-8.3)	2.2- 2.6	0.349
Ascorbic acid (µg/l)	3.74 (0.0-17.0)	3.03- 4.44	6.37 (0-18)	4.9- 8.1	0.001	3.74 (0.0-17.0)	3.03- 4.44	6.49 (0.0-13.5)	4.2- 8.7	0.014
Retinol (mmol/l)	3.0 (1.5-4.0)	2.91- 3.13	3.2 (2.9-3.1)	2.9- 3.3	0.007	3.0 (1.5-4.0)	2.91- 3.13	3.2 (2.4-3.9)	2.9- 3.4	0.433
α -T (mmol/l)	18.0 (5.8-27.3)	17.2- 18.9	19.6 (7.3-37.7)	18.3- 20.9	0.002	18.0 (5.8-27.3)	17.2- 18.9	19.3 (7.2-37.2)	17.9- 21.4	0.018
α -T/ cholesterol	3.3 (1.2-12.1)	3.18- 3.52	4.3 (1.2-8.3)	4.19- 4.52	0.000	3.3 (1.2-12.1)	3.18- 3.52	4.2 (1.2-8.3)	3.7- 4.6	0.000
α -T/ choles+TG	2.2 (1.0-8.0)	2.05- 2.34	2.92 (1.0-6.1)	2.71- 2.95	0.000	2.2 (1.0-8.0)	2.05- 2.34	2.8 (1.0-5.2)	2.56- 3.22	0.000

HDL-C = high density lipoprotein cholesterol; LDL-C = low density lipoprotein cholesterol; TG = triglyceride; α -T = α -tocopherol;

^a Mann-Whitney *U*-Wilcoxon Rank Sum *W* test

statistically significant differences were found for lipid profiles and the antioxidant vitamins (A, E, C) among the healthy compared with the variously diseased priest subjects, except the serum triglyceride of diabetes mellitus + complication and heart disease + complication groups, and the body weight of the dyslipidemia + complication group were significantly higher than the others (Table 2).

The numbers and percentages of individuals, with vitamin deficiencies and dyslipidemia, in the priest and control subjects are shown in Table 3. Priest subjects had decreased α -tocopherol levels of 28% and ascorbic acid levels of 65%; while the controls had decreased

α -tocopherol and ascorbic acid levels of 20% and 7.7%, respectively. A total of 67.8% and 54.4% of the priest and control subjects, respectively, had cholesterol concentrations of ≥ 5.18 mmol/l. A cholesterol concentration of ≥ 6.48 mmol/l was found in 33%, 13.3% and 8.6% of the male priests, and the male and female control subjects, respectively. However, the prevalence of low HDL-C (HDL-C ≤ 0.91 mmol/l) was found to be 1.8% for the priest subjects and 1.4% for the controls.

Table 4 shows the correlation coefficients between various parameters for the priest and control subjects. Statistically significant associations were found

Table 2
Median, range, and 95% CI of age, weight, lipid profiles, serum ascorbic acid, retinol, and α -tocopherol in priests with various diseases.

Parameter	Total priest (N=112)							
	Healthy (N=33)		DM+complication (N=39)		Dyslipid+complication (N=22)		HD+complication (N=18)	
	Median (range)	95%CI	Median (range)	95% CI	Median (range)	95%CI	Median (range)	95%CI
Age (yr)	46 (21-67)	41-51	52 (31-70)	48-56	53 (32-65)	48-57	54 (29-67)	48-59
Weight (kg)	63 (39-96)	59.7-67.1	65 (37-92)	61-69	72 ^a (40-95)	66-78	63 (53-88)	58-67
Cholesterol (mmol/l)	5.97 (3.5-8.2)	5.7-6.3	6.05 (2.5-8.4)	5.6-6.5	6.15 (3.5-8.5)	5.6-6.7	6.10 (3.9-10.5)	5.3-6.9
HDL-C (mmol/l)	1.7 (1.1-2.7)	1.6-1.8	1.6 (0.8-2.3)	1.5-1.7	1.5 (0.9-2.3)	1.3-1.7	1.7 (1.1-2.7)	1.5-1.9
LDL-C (mmol/l)	3.8 (1.8-5.9)	3.5-4.1	3.7 (0.9-6.0)	3.3-4.1	3.8 (1.5-5.5)	3.4-4.2	3.8 (1.5-7.5)	3.1-4.5
LDL-C/HDL-C	2.2 (1.6-2.4)	2.1-2.3	2.2 (1.1-2.0)	2.1-2.3	2.7 (1.0-2.4)	2.6-2.8	2.2 (1.1-2.0)	2.1-2.3
TG (mmol/l)	0.97 (0.49-3.25)	0.86-1.14	1.25 ^a (0.54-6.8)	0.92-1.59	1.08 (0.37-3.06)	0.76-1.37	1.34 ^a (0.72-2.71)	1.06-1.39
Ascorbic acid (μ g/l)	5.0 (0.0-17.0)	3.7-6.3	3.2 (0.0-12.0)	2.0-4.2	3.9 (0.0-13.0)	2.4-5.0	1.3 (0.0-12.0)	0.8-1.8
Retinol (mmol/l)	2.97 (1.46-3.98)	2.79-3.14	3.04 (1.47-4.01)	2.82-3.26	3.07 (2.09-3.87)	2.86-3.28	3.05 (2.33-3.99)	80-95
α -T (mmol/l)	18.0 (9.6-33.8)	16.8-19.3	18.5 (5.8-27.3)	17.0-20.0	17.6 (12.9-23.8)	16.2-19.1	19.5 (13.4-24.4)	18.2-20.8
α -T/cholesterol	3.4 (2.0-4.8)	3.18-3.52	3.6 (2.1-12.1)	3.00-4.00	3.5 (2.3-6.8)	3.00-3.90	3.4 (2.2-5.0)	3.0-3.7
α -T/choles+TG	2.2 (1.5-3.7)	2.05-2.34	2.3 (1.1-8.0)	1.98-2.60	2.2 (1.5-3.6)	2.05-2.40	2.3 (1.4-3.5)	2.00-2.60

DM = diabetes mellitus; Dyslipid = dyslipidemia; HD = heart disease
HDL-C = high density lipoprotein cholesterol ; LDL-C = low density lipoprotein cholesterol;
TG = triglyceride; α -T = α -tocopherol
^a Mann-Whitney U-Wilcoxon Rank Sum W test

between α -tocopherol, cholesterol, LDL-C, triglyceride, and serum retinol. A positive correlation was found between age, retinol, and serum α -tocopherol. A negative correlation was found between cholesterol, HDL-C, LDL-C, and the serum α -tocopherol/cholesterol ratio. In addition, a negative correlation was found between weight, cholesterol, LDL-C, triglyceride, and the serum α -tocopherol/(cholesterol+ triglyceride) ratio in priest and control subjects.

DISCUSSION

In this study, lower serum ascorbic acid, retinol, and α -tocopherol levels were found in the priest subjects, when compared with the control subjects (Table 1). In the subjects studied here, age appeared to influence serum α -tocopherol concentrations in an independent way (Table 3). Data from the literature show that plasma α -tocopherol appears to increase with age in most longitudinal (Haller *et al*, 1996; Ohtvall *et*

Table 3
Number and percentage of individuals with abnormal vitamin A, E, and C, and dyslipidemia in priest and control subjects.

Parameter	Male (N=202)				Female		Total			
	Priest (N=112)		Control (N=90)		Control (N=119)		Control (N=209)		All (N=321)	
	N/Total	%	N/Total	%	N/Total	%	N/Total	%	N/Total	%
Vitamin deficiency										
Retinol <0.7mmol/l*	0	0	0	0	0	0	0	0	0	0
α -T <16.2 mmol/l*	28/100	28.0	29/90	32.2	13/119	10.9	42/209	20.1	70/309	22.6
vitamin C <5mg/l	73/112	65.0	30/90	33.3	35/116	30.2	65/206	31.5	83/242	34.3
Dyslipidemia										
Choles \geq 5.18 mmol/l	76/112	67.8	55/90	61.1	57/116	49.1	112/206	54.4	188/318	59.1
Choles \geq 6.48 mmol/l	37/112	33.0	12/90	13.3	10/116	8.6	22/206	10.7	59/318	18.5
HDL-C \leq 91 mmol/l	2/112	1.8	2/90	2.2	1/116	0.9	3/206	1.4	5/318	1.6
LDL-C \geq 3.89 mmol/l	50/112	44.6	15/90	16.7	17/116	14.6	32/206	15.5	82/318	25.8
TG \geq 2.26 mmol/l	6/112	5.3	10/90	11.1	1/116	0.9	11/206	5.3	17/318	5.3

*Maiani *et al*, 1993; Morrisey *et al*, 1993; Olmedilla *et al*, 1997.

Table 4
Correlation coefficients of age, weight, ascorbic acid, retinol, α -tocopherol/cholesterol and lipid profiles in priest and control subjects.

Parameter	Ascorbic acid	Retinol	α -tocopherol	α -tocopherol/ cholesterol	α -tocopherol/ (chol+TG)
Age	-0.126	0.114	0.233 ^b	0.030	-0.049
Weight	-0.057	0.093	0.089	-0.032	-0.189 ^a
Ascorbic acid	1.000	-0.060	0.079	0.021	-0.029
Retinol	-0.060	1.000	0.270 ^b	0.089	0.043
α -tocopherol	0.079	0.270 ^b	1.000	0.736 ^b	0.677 ^b
Cholesterol	0.052	0.179 ^b	0.084	-0.566 ^b	-0.451 ^b
HDL-C	0.026	0.030	-0.026	-0.316 ^b	-0.029
LDL-C	0.019	0.167 ^b	0.086	-0.524 ^b	-0.361 ^b
Triglyceride	0.019	0.172 ^b	0.095	-0.095	-0.489 ^b

^aSignificant difference: p<0.05

^bSignificant difference: p<0.01

al., 1996) and cross sectional studies (Battisti *et al.*, 1994; Hallfrisch *et al.*, 1994).

No statistically significant differences were found for retinol among male and female healthy control subjects (data not shown). Most studies have found no difference between genders for plasma retinol in healthy people (Borel *et al.*, 1998; Winklhofer-Roob *et al.*, 1997). Regarding α -tocopherol, Woo *et al.* (1988) found a higher level in women, whereas no difference was reported by Hallfrisch *et al.* (1994).

The median vitamin C concentration values in the priest subjects were lower than those of the control subjects (Table 1). Serum vitamin C concentrations in the males were lower than the female control subjects. More than 50% of all priest subjects had vitamin C levels below the normal cut-off point of 5 mg/l. In a previous report (Mahaisiriyodom *et al.*, 1997), it was found that not only the antioxidant vitamin C, which is responsible for metabolizing reactive oxygen species (ROS), but also antioxidant vitamins A and E were significantly lower than the normal groups. The low levels of vitamin A, E, and C concentrations in the disease and control priest subjects might have resulted from high-activity metabolism and might be related to decreased antioxidant enzymes and non-enzymes that require a reducing agent such as vitamins A, E, and C to maintain the situation.

In addition, higher levels of cholesterol, LDL-C, and LDL-C/HDL-C were present in the priest subjects (Table 1). A prevalence of dyslipidemia (67.8% cholesterol of ≥ 5.18 mmol/l, 44.6% LDL-C ≥ 3.89 mmol/l) and serum vitamin deficiencies (28% of α -tocopherol < 16.2 μ mol/l and 65% of ascorbic acid < 5 mg/l) were observed in the priest subjects (Table 2). These appear to have been due to poor dietary intake that may increase the oxidation of LDL and lead to a high risk of coronary artery disease (CAD), hypertension, diabetes mellitus, and cancer.

In the control group, women had slightly lower serum retinol concentrations than men that may reflect lower liver stores in women, but could also be due to differences in retinol metabolism. Serum retinol binding protein concentrations fluctuate during the menstrual cycle and increase with estrogen therapy (Riemersma *et al.*, 1991), making it unlikely that estrogen-induced differences in retinol metabolism would account for the lower concentrations in women.

A negative correlation was found between weight, cholesterol, LDL-C, triglyceride, and serum α -tocopherol/(cholesterol+ triglyceride) ratios in priest and control subjects (Table 3). The concentration of

the lipid-soluble molecule vitamin E, carried by lipoproteins in the bloodstream, was previously reported to correlate closely with that of total cholesterol (Riemersma *et al.*, 1991; Bjornson *et al.*, 1976).

Strongly significant differences in vitamin E concentrations between the priest and the control subjects were noted in the present study after lipid adjustment, as described by Riemersma *et al.* (1991). Earlier studies (Bjornson *et al.*, 1976; Horwitt *et al.*, 1972) have shown that normolipidemic subjects have the largest amount of plasma vitamin E in the LDL fraction, whereas subjects with elevated triacylglycerol concentrations have the largest amount of plasma vitamin E in the VLDL fraction.

The results of the present study have provided further support for the suggestion that low concentrations of antioxidant vitamins may be an important risk factor for coronary artery disease (CAD), hypertension, diabetes, chronic inflammatory diseases, ageing, Alzheimer's disease, and cancer. The results of epidemiological studies of the relation between antioxidant vitamins and diseases have not been entirely congruent. The basis for lower serum concentrations of retinol, α -tocopherol, and ascorbic acid in diseased and non-diseased priest subjects compared with control subjects remains speculative, but several factors that have been shown to have an impact on the immune system, such as dietary differences, smoking, alcohol intake, and variability in body compartment size are likely explanations. Furthermore, the priest group had been informed about a lipid-lowering diet, and increasing vegetable and fruit intake at the time of the investigation. The dietary instructions were aimed at increasing the intake of polyunsaturated fatty acids and hence, vitamins A, E, and C that may have decreased any existing differences in vitamin A, E, and C concentrations between the priest and control subjects. Prospective randomized controlled trials are clearly needed to answer the question of what would be the truly beneficial role for antioxidants in preventing many diseases, and a better understanding of the highly complex process.

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