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Relationship Among Body Mass Index, Nutrient Intake and Antioxidant Enzyme Activity of Postmenopausal Women

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Abstract

To elucidate the relationship among body mass index, nutrient intake and blood antioxidant capacity in the postmenopausal period, 60 women residing in Iksan area were recruited. Body mass index (BMI) was calculated base on height and weight, and food and nutrient intakes were estimated by 24-hour recalls of 3 non-consecutive days. Parameters of antioxidant capacity including the activities of superoxide dismutase (SOD), glutathione peroxidase (GPx), catalase (CAT) and total antioxidant capacity (TA) were measured in fasting blood samples from the subjects. The average age, height, weight and BMI of the subjects were 65 years, 151.1cm, 59.5 kg and 26.0 m/kg^2, respectively. The macronutrient intake rate of carbohydrate : protein : fat were 65:17.5:17.5; the mean intakes of energy and protein were 1532.7 kcal (86.3% of RDA) and 67.1 g (122.0% of RDA) respectively. The mean intakes of phosphorus, vitamin A, niacin and vitamin C were higher than Recommended Daily Allowance (RDA) for Koreans. On the other hand, calcium and riboflavin intakes were only 84.6% and 70.4% of RDA. Among the parameters of antioxidant capacity, SOD activity was significantly lower in lean subjects (BMI<20) than in the normal or overweight subjects (BMI≥20) ($p<0.05$). TAs of the subjects with the highest intakes of vegetables and fruits were significantly higher than those of subjects with lower intakes ($p<0.05$). Antioxidant capacity was compared among subjects according to 3 different nutrient intake levels according percentage of RDA for Koreans for selected nutrients with the following results: The high protein and niacin groups exhibited significantly lower TA status than those of the other intake groups ($p<0.05$). In conclusion, the low BMI was associated with lower SOD activity in postmenopausal women. Higher consumption of fruits and vegetables was associated with higher TA. When protein and niacin intakes were excessive, SOD activity and TA tended to be low. SOD and TA, among antioxidant indexes, seemed to be mostly influenced by other factors. Therefore, more studies on the effects of nutritional intake and the activity of antioxidant enzyme should be conducted.

Key words: superoxide dismutase, glutathione peroxidase, catalase, total antioxidant capacity

INTRODUCTION

The average life span in modern society is increasing due to improved economies and advances in medical technologies. In particular, the average life span of postmenopausal women (79.2) is higher than that of men (71.7) (1). The rate of obesity in menopausal women increases due to several causes including the change that are also associated with chronic degenerative diseases. Many domestic and foreign studies have implicated singlet oxygen as one cause of chronic degenerative diseases, such as hypertension, arteriosclerosis, cardiac disorders (2-8).

Singlet oxygen is unstable oxygen molecule with an unpaired electron. The process of metabolism in living bodies requiring oxygen necessarily produces superoxide anion (O_2-), hydrogen peroxide (H_2O_2), hydroxyl radical (OH.), single oxygen (.O_2-), organic free radical (R), peroxyl free radical (ROOH) and hypochlorous acid (HOCL) (9).

Our bodies constantly produce singlet oxygen through the processes of energy production and normal metabolism and in the immune system. Overproduced singlet oxygen oxidizes unsaturated fatty acid, lipid and cholesterol in the body and produces lipid peroxide which are destructive to cells in the body (2) and impedes the flow of blood by sticking to the wall of blood vessels. It also destroys the functionality of cells by degrading the proteins associated with cell membranes (2) and impairs membrane fluidity by blending the lipid and protein of cell membranes, and thus makes them fragile and porous resulting in easy penetration of bacteria and viruses. Singlet oxygen also exposes the nucleus and genetic material by tearing nuclear membranes resulting in mutation

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and reorganizes or destroys genetic information and threatens the immune system by injuring immune cells (2,10).

Therefore it is reported that accumulated cellular injury caused by singlet oxygen causes several chronic diseases and accelerates aging (11,12). In addition to environmental factors, excessive drinking and overeating are recently regarded as major causes of singlet oxygen production (13-16). However, the body has enzymatic and the non-enzymatic systems to defend oxidative stress caused by singlet oxygen. The enzymatic system which can be synthesized in a living body includes oxidative superoxide dismutase (SOD), glutathione peroxidase (GPx), catalase (3,9) and the non-enzymatic system includes vitamin E, vitamin C, β-carotene, phenolate and selenium (17-23).

Some studies on the relationship between the change of total anti-oxidative capacity or immunity in the development process of diseases in patients with chronic cardiovascular diseases, diabetes and cancers have been conducted in Korea (8,24,25). However few studies on the relationship among nutrient intake, BMI and antioxidant enzyme activity of postmenopausal women have been conducted in Korea.

Therefore we studied the relationships among body mass index, nutrient intake and activity of antioxidant enzyme in postmenopausal women.

MATERIALS AND METHODS

Subjects

Menopause is when menstruation is suspended for one year after the last menstruation due to reduced hormones from the ovary (26). Sixty postmenopausal women from the age 50～77, attending a seniors' college and living in Iksan-city, on July in 2002 were selected as the main subjects. The subjects experienced natural menopause without hysterectomy, except those who had thyroid and kidney problems. We studied anthropometric measurements, collected blood and recorded food intake for three days. Each participant completed a questionnaire conducted by investigators. We explained the objectives, methods, contents and necessity of clinical tests to subjects and received their consent to participate in the tests.

Anthropometric measurements

The subject's heights and weights were measured while in an upright position without shoes using an automatic physical measuring machine (DS-102, JENIX, Korea). The BMI [body mass index=weight (kg) / height $(m)^2$] was calculated base on height and weight. The percentage of body fat (%) was calculated based on age and height using a body fat measuring instrument (TBF-105 TANITA, Japan). Waist and hips were measured with a measuring tape. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using an automatic sphygmomanometer (BP-750A, NISSEI, Japan).

Nutrient and food intake

Experienced surveyors interviewed the subjects and studied food intake for 3 non-consecutive days, using model tableware and food to assist in the dietary recall method. Nutrient intake data was analyzed using (Separating 'beverage and liquor' into 'beverage' and 'liquor') a nutritional analysis program, Can-pro (27) and Food Composition Table (28) food recall data was also used to obtain antioxidant nutrient intakes. We selected fruits, eggs, soy & soy products, milk & milk products and vegetable which seem to be related with antioxidant enzyme. We classified intake for 3 days into three groups, considering the daily recommended allowance of Food Guideline for Koreans (29) and the distribution of food intake for each subject and compared them. We classified fruits into 100 g, 100～200 g and more than 200 g based on a recommended allowance of Food guideline for 100 g.

We classified eggs into 25 g (a half), 25～50 g (one) and 50 g (more than one) based on a 50 g, the weight of an egg. We sorted soybean & soybean products into 100 g, 100～200 g and more than 200 g servings based on total 100 g of soy from 80 g of bean curd 80 g and 20 g from soybeans as recommended by the Food guidelines. We arranged milk & milk products into 100 g, 100～200g and more than 200 g based on a cup of milk (200 g). We categorized vegetable servings into 500g, 500～1,000 g and more than 1,000 g, based on the intake distribution of the subjects.

Analysis of antioxidant enzyme activity

We collected 20 mL venous blood after 12 hours fasting and held it is at room temperature for 30 minutes and then 10 mL whole blood was put into a heparin-containing tube and used for measuring plasma antioxidant enzymes. The remaining 10 mL serum was separated by density gradient centrifugation at 2,500 rpm for 15 minutes and kept it in a freezer at -70°C and used for analysis.

Superoxide dismutase: The activity of SOD was assayed in 1.0 mL heparin-treated plasma, using a protocol based on Flohe method (30). Xanthin produces superoxide by xanthine oxidase. This superoxide radical forms Formazan dye through reacting with I.N.T (2-[4-iodophenyl]-3-[4-introphenol]-5phenyl-tetrazolium chloride). We measured the degree of suppression of this reaction as an indicator of SOD activity.

Glutathione peroxidase: GPx activity was determined by a UV method, using 0.05 mL of heparin-treated plasma, based on Paglia & Valentine's method (31). We measured the degree of decrease in optical density at 340 nm when glutathione is reduced by GR and NADPH.

Serum catalase: Serum catalase activity was determined according to the Aebi method (32). We placed 50 mmol/L Na-K phosphate buffer (pH 7.0) and a substrate, 1.0 mL H_2O_2 into 0.2 mL serum and activated it at 37°C for 1 minute. Then 32.4 mmol/L ammonium molydate solution was added and held at 37°C for 1 minute. Optical density then measured at 405 nm using a spectrophotometer (Photometer 4020, Japan).

Total antioxidant capacity: Serum was cultivated with ABTS (2,2'-Azino-dl-[3-ethylbinzthiazoline sulphonate]) with peroxidase and H_2O_2, and measured the appearance of a positive ion at 600 nm which forms a stable bluish green molecule creates by ABTS (33) was measured. This method can show the amount of singlet oxygen in blood and repress this reaction is suppressed by any antioxidant material present. Total antioxidant status (RANDOX, United Kingdom) was used as a reagent; activity was measured in an automatic analyzer (HITACHI 7150, Japan) and resulted were expressed as mmol/L.

Statistical analysis

Data were statistically analyzed using a SAS program (Version 8.2). Significance of differences among three groups were compared using Duncan's multiple range test at a $p<0.05$ after ANOVA.

RESULTS AND DISCUSSION

General information

Anthropometric measurements: The age distribution of 60 subjects (Table 1) was: 20 (age group, 50~59), 21 (age group, 60~69) and 19 (age group, 70~77). The average age, height and weight of all subjects were 65 years, 151.1 cm and 59.5 kg, respectively, which was a little shorter, but relatively heavier for their age than the 154 cm and 54 kg suggested by Korean physical standards for citizens aged 65~74 (29). Therefore, the average BMI was 26.0, which was higher than the 22.8 suggested for the age group in Korean physical standards (29). Body fat content was also higher at 38.4%. WHR was within a normal range (75~90%) at an average of 87.4%. The average SBP and DBP were 145.5 mmHg and 77.7 mmHg, respectively, lower than 160 mmHg, the hypertension standard of WHO. SBP, however, was higher than Korean standard for normal SBP of less 140 mmHg. There were no differences in height between the fifties, 152.2 cm and sixties, 152.3 cm. But the seventies age group was shorter at 148.7 cm ($p<0.05$). The SBP of the fifties group was significantly lower at 133.3 mmHg compared to the sixties and seventies groups at 151.1 mmHg and 152.2 mmHg, respectively ($p<0.05$).

Nutrients & food intake

Nutrient intakes and the percentages of the RDA are shown in Table 2. Intakes of macronutrients, carbohydrate : protein : fat were 65:17.5:17.5%. The average energy intake was 1532.7 kcal, 86.3% of the recommended intake, lower than the 102.7% in the 50~64 age group and 98.2% in the over 65 age group reported in the 2001 National Health & Nutrition Survey (34). The intake of protein was 67.1 g, 122% of the recommended intake. The intakes of phosphorus, vitamin A, niacin and vitamin C were higher than the recommended intakes, but the intakes of calcium and riboflavin were lower than the recommended intake. The mean intake of calcium was 592.2 mg, 84.6% of the recommended intake, higher than 73.4% in the 50~64 age and 61.2% in the over

Table 1. Anthropometric measurements in postmenopausal women

Variables	Total (n=60)	50~59 yrs (n=20)	60~69 yrs (n=21)	70~77 yrs (n=19)
Height (cm)	151.1±5.5[1)]	152.2±5.7[a2)]	152.3±5.1[a]	148.7±5.1[b]
Weight (kg)	59.5±8.6	60.3±89.0	61.2±7.7	56.8±9.0
BMI (kg/m^2)[3)]	26.0±3.2	26.1±3.6	26.3±2.7	25.6±3.1
Waist (cm)	85.8±8.9	82.9±9.1	87.3±6.6	87.1±10.5
Hip (cm)	98.0±6.6	96.5±6.4	98.8±5.9	98.8±7.6
WHR[4)]	87.4±5.8	85.7±5.8	88.3±3.3	88.1±7.7
Body fat (%)	38.4±7.3	38.6±8.0	38.4±5.2	38.1±8.8
SBP[5)] (mmHg)	145.5±21.4	133.3±17.6[b]	151.1±20.9[a]	152.2±21.1[a]
DBP[6)] (mmHg)	77.7±10.0	76.7±9.7	79.5±9.0	76.7±11.6

[1)]Mean±standard deviation.
[2)]Means with different superscripts within a row are significantly different at α=0.05 as determined by Duncan's multiple range test.
[3)]Body mass index. [4)]Waist hip ratio. [5)]Systolic blood pressure. [6)]Diastolic blood pressure.

Table 2. Percent RDA values and means daily nutrient intakes in postmenopausal women

Nutrients	Total (n=60)	50~59 yrs (n=20)	60~69 yrs (n=21)	70~77 yrs (n=19)
Energy (kcal)	1532.7±420.4[1)]	1477.6±300.5	1664.5±534.8	1445.1±366.6
% RDA	86.3	77.8	93.2	87.7
Protein (g)	67.1±27.6	61.2±21.4	76.4±32.6	62.9±25.8
% RDA	122.0	111.4	139.0	114.4
Fat (g)	29.8±17.0	26.6±7.5	35.3±22.7	27.1±16.2
Carbohydrate (g)	249.1±56.7	246.4±52.0	262.3±67.6	237.3±47.2
Calcium (mg)	592.2±243.9	467.7±156.3$^{b2)}$	701.4±245.3^{a}	602.5±266.6^{ab}
% RDA	84.6	66.8	100.2	86.1
Phosphorus (mg)	1078.3±387.0	959.9±291.8^{b}	1253.4±448.4^{a}	1009.4±348.1^{b}
% RDA	154.0	137.1	179.1	144.2
Iron (mg)	11.9±4.0	10.2±2.7^{b}	14.1±4.2^{a}	11.3±3.9^{b}
% RDA	99.2	85.0	117.2	94.4
Vitamin A (R.E)	882.4±553.1	827.7±379.9	1073.8±723.1	728.6±445.6
% RDA	126.1	118.2	154.4	104.1
Vitamin B1 (mg)	1.1±0.5	1.0±0.2	1.2±0.7	1.0±0.3
% RDA	106.7	102.4	120.4	96.0
Vitamin B2 (mg)	0.8±0.3	0.8±0.2	0.9±0.4	0.8±0.3
% RDA	70.4	68.3	78.3	64.0
Niacin (mg)	15.1±7.0	14.4±5.5	16.1±8.7	14.9±6.6
% RDA	116.5	110.9	123.7	114.4
Vitamin C (mg)	95.5±35.7	100.0±36.9	102.8±38.5	82.7±29.1
% RDA	136.4	142.8	146.8	118.1

[1)]Mean±standard deviation.
[2)]Means with different superscripts within a row are significantly different at α=0.05 as determined by Duncan's multiple range test.

65 age group shown in the 2001 National Health & nutrition Survey (34). The intake of riboflavin was the lowest level, 1.1 mg, 70.4% of the recommended intake. The intake of iron approximately approached 100% as 11.9 mg, 99.2% of the recommended intake. In comparison of nutrient intake by an age group, the sixties group had the highest intake in calcium, phosphorus and iron compared with the fifties and seventies groups ($p<0.05$). The sixties group had the highest intakes of most nutrients.

The average intake of Cereals (Table 3) was 258.5 g, lower than the average intake of women subjects, 50 ~64 and over 65, 319.0 g and 291.8 g shown in 2001 National Health & Nutrition Survey (34). However, the average intake of eggs was 13.7 g, higher than women subject, 50~64 and over 65, 11.4 g and 8.4 g shown in 2001 National Health & Nutrition Survey (34). The average intake of soy foods was 56.3 g, higher than women subject, 50~64 and over 65 (33.5 g and 30.1 g) reported in the 2001 National Health & Nutrition Survey (34).

By an age group, there was a significant difference in the intake of eggs; the seventies group showed the highest intake, 18.8 g, and the sixties and fifties groups 15.6 g and 6.8 g, respectively ($p<0.05$). There was a significant difference in the intake of beverages; the fifties group showed the highest intake, 85.9 g, compared with the sixties and seventies group at 38.8 g and 23.7 g, respectively ($p<0.05$). However, the fifties group had the lowest intake of seasonings, 18.6 g, compared with the sixties and seventies groups (36.8 g and 21.0 g, $p<0.05$).

Activity of antioxidant enzymes

Anthropometric measurements & activity of antioxidant enzyme: The comparison between anthropometric measurements and activity of antioxidant enzymes in menopausal women is shown in Table 4. We classified age groups into fifties, sixties and seventies and analyzed the activity of enzyme by age. The higher ages had the lowest SOD activities, but not significantly; at 143.8 U/mL for the fifties, 139.3 U/mL for the sixties, and 131.9 U/mL for the seventies. There was no significant difference by age in GPx, CAT and TA.

The subjects were classified into four groups according to BMI (Fig. 1): underweight (BMI<20), normal weight (20≤BMI<25), overweight (25≤BMI<30), obese (30≤ BMI). SOD activity in the underweight group was lower than those in the other groups, the same was true for GPx, CAT and TA. Therefore, weight and height seem to be related with the activity of antioxidant enzyme. This shows that underweight along with overweight can impede antioxidant enzyme activity in the aged and in postmenopausal women. Among various antioxidant enzymes only SOD showed a significant difference by BMI. Many studies have shown SOD to the most sensi-

Table 3. Dietary intake categorized by food group in postmenopausal women (g)

Food groups	Total (n=60)	50~59 yrs (n=20)	60~69 yrs (n=21)	70~77 yrs (n=19)
Potatoes	20.8±35.9[1)]	20.7±46.0	18.9±27.7	22.9±33.4
Cereals	258.5±68.8	260.9±70.1	266.6±77.1	246.8±59.1
Fruits	166.1±197.4	190.2±189.2	181.2±243.9	123.9±144.9
Eggs	13.7±18.0	6.8±7.5^{a}[2)]	15.6±20.5^{ba}	18.8±21.3^{a}
Sugars	7.1±8.3	7.0±5.7	9.3±11.8	4.9±5.2
Soy foods	56.3±47.1	45.5±29.4	66.1±66.1	56.9±35.4
Mushrooms	2.8±5.8	4.7±7.4	1.0±3.2	3.0±5.9
Fishes	71.1±55.0	62.5±52.9	81.5±58.1	68.8±54.6
Milk	47.4±63.2	51.3±65.2	56.4±75.6	33.3±44.0
Oils	4.5±3.9	4.4±2.4	5.6±5.7	3.3±2.2
Meats	43.7±69.8	39.1±28.3	52.0±104.4	39.3±53.6
Beverages	49.7±86.8	85.9±133.5^{a}	38.8±50.7^{ba}	23.7±26.8^{b}
Alcoholic beverage	33.4±114.6	31.2±70.3	43.1±154.6	24.9±105.3
Seasonings	25.7±20.5	18.6±10.9^{b}	36.8±26.6^{a}	21.0±15.6^{b}
Seeds and Nuts	5.2±9.8	2.8±5.8	6.4±11.5	6.5±11.1
Vegetables	325.0±111.1	325.3±89.5	339.7±117.3	308.5±127.1
Seaweeds	4.3±12.2	1.9±2.5	4.8±15.3	6.2±14.4

[1)] Mean±standard deviation.
[2)] Means with different superscripts within a row are significantly different at α=0.05 as determined by Duncan's multiple range test.

Table 4. Antioxidant enzyme activities by anthropometric measurements

	Variables	n	SOD (U/mL)	GPx (U/mL)	CAT (kU/L)	TA (mmol/L)
Age	50~59 yrs	20	143.8±18.5[1)]	1227.2±239.81	343.6±192.5	1.17±0.16
	60~69 yrs	21	139.3±11.7	1292.0±267.16	296.4±181.3	1.19±0.14
	70 yrs<	19	131.9±18.4	1301.9±332.51	301.7±226.5	1.12±0.11
BMI	<20	3	114.1±18.5^{b}[2)]	1071.5±209.4	158.6±10.0	1.09±0.08
	20~24	15	134.0±13.7^{ba}	1269.3±225.3	328.7±230.7	1.17±0.17
	25~29	35	140.9±15.2^{a}	1284.5±305.6	302.4±179.6	1.15±0.14
	30≤	7	147.7±17.0^{a}	1327.2±275.9	380.4±218.8	1.24±0.08

[1)] Mean±standard deviation
[2)] Means with different superscripts within a column are significantly different at α=0.05 as determined by Duncan's multiple range test.

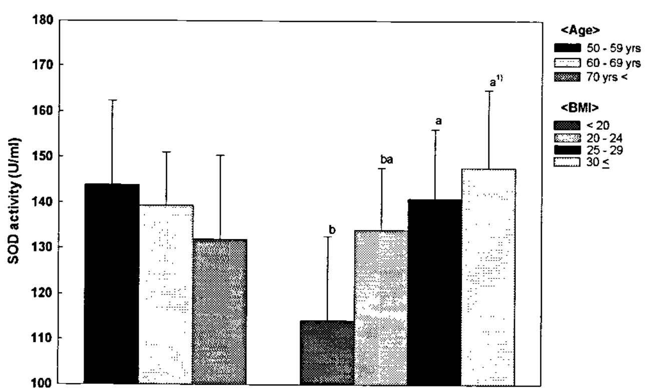

Fig. 1. Comparison of superoxide dismutase activities by age and body mass index.
[1)] Means with different superscripts are significantly different at α=0.05 as determined by Duncan's multiple range test.

tive response of SOD in antioxidant enzyme activity. However, there are few studies on the mechanisms involved in the modulation of SOD activity or activities of other antioxidant enzymes such as GPx, GAT and TA. More studies on mechanism should be actively conducted based on this study.

Nutrients & food intake and activity of antioxidant enzyme

The subjects categorized according to nutrient intake into three groups, under 75%, 75~125% and over 125% of the Korean RDA and compared for of antioxidant enzyme activities for each nutrient (Table 5). Only two subjects consumed over 125% of the recommended intake in energy, not enough to obtain useful data. SOD activity of the group consuming 75% of the RDA for protein was significantly higher at 1.30 mmol/L compared with 1.15 mmol/L in the 75~125% and over 125% groups ($p<0.05$). The group consuming less than 75% of the RDA for vitamin C showed a significantly higher level of SOD activity, 153.9 U/mL, compared with the 75~125% and over 125% groups at 136.5 U/mL and 137.5 U/mL, respectively ($p<0.05$).

The under 75% niacin group showed a significant higher SOD level, 144.5 U/mL, compared with the 75~125% and 125% groups at 139.9 U/mL and 130.5 U/mL, respectively ($p<0.05$). The under 75% group exhibited a higher TA level than the group over 125% ($p<0.05$). The above results demonstrate that higher nutrients intakes tended to be associated with lower antioxidant activity levels. Salonen et al. (35) observed a decrease in serum lipid peroxide, decreased platelet aggregation and increased activity of GPx when antioxidant nutrients were given to male subjects who had insufficient antioxidant nutrients. When vitamin E or selenium was given to them, Urano et al. (36) observed increased antioxidant enzyme activities.

A high level of antioxidant enzyme activity in the group with a low intake of vitamin C or niacin, may have affected from the antioxidant enzyme activity of the 50~59 age group, which had a relatively low intake of vitamin C, compared with the over 60 age group. It is considered that not only the intake of vitamin C or niacin, but the intake of other nutrients affected antioxidant enzyme activity. This is different from observations that the activities of antioxidant enzymes are related to decreases in antioxidant nutrients like vitamin E, which is required for maintaining the structural integrity of cell membranes. Therefore more studies on effects of nutrient intake on activities of antioxidant enzyme should be conducted.

There are few studies on the effects of general nutrition status on antioxidant enzyme activity, except with vitamin and minerals which are known as antioxidant nutrients. Therefore, we analyzed the activity of antioxidant enzyme according to levels of food and nutrient intake. We compared the activity of antioxidant enzymes in subjects with different intake levels of various food group (Table 6). TA of subjects who consumed more

Table 5. Antioxidant enzyme activities by percent RDA values of daily nutrient intakes

Nutrients	% RDA	n	SOD (U/mL)	GPx (U/mL)	CAT (kU/L)	TA (mmol/L)
Energy	<75	20	141.2±15.3[1)]	1275.1±274.5	298.8±189.5	1.19±0.16
	75~125	38	136.8±17.5	1273.0±282.8	339.7±196.6	1.15±0.13
	125≤	2	-[2)]	-		-
Protein	<75	5	145.5±16.4	1199.2±303.2	247.9±318.2	1.30±0.25[a3)]
	75~125	35	139.6±16.4	1255.5±274.0	364.1±175.8	1.15±0.13[b]
	125≤	20	133.8±17.3	1342.0±285.7	250.4±179.2	1.15±0.13[b]
Vitamin A	<75	16	140.4±16.2	1246.1±311.9	285.3±175.2	1.16±0.09
	75~125	17	132.6±16.6	1247.4±252.8	301.4±192.3	1.16±0.13
	125≤	27	140.5±16.9	1304.5±275.4	336.6±213.5	1.17±0.17
Vitamin C	<75	5	153.9±9.9[a]	1459.6±276.7	279.3±297.6	1.25±0.15
	75~125	23	136.5±11.9[b]	1194.3±293.8	326.2±118.4	1.13±0.11
	125≤	32	137.5±18.9[b]	1295.6±258.7	312.6±221.4	1.18±0.16
Thiamin	<75	11	137.4±9.1	1239.2±272.2	350.7±246.7	1.14±0.12
	75~125	33	139.7±18.8	1289.9±291.1	335.5±194.3	1.18±0.15
	125≤	16	136.3±15.1	1255.3±260.7	254.9±172.7	1.15±0.14
Riboflavin	<75	40	141.2±16.4	1261.2±258.3	299.4±186.8	1.17±0.15
	75~125	17	131.8±16.4	1282.4±324.9	350.1±182.7	1.15±0.14
	125≤	3	-	-	284.8±408.6	1.16±0.05
Niacin	<75	10	144.5±13.6[a]	1264.5±263.0	301.0±223.6	1.23±0.19[a]
	75~125	32	139.9±16.7[ba]	1234.9±299.7	324.2±157.5	1.17±0.14[ba]
	125≤	18	130.5±17.0[b]	1369.4±227.2	305.7±245.1	1.11±0.09[b]
Calcium	<75	25	143.7±15.6	1186.8±235.6	332.8±200.6	1.18±0.16
	75~125	29	134.8±16.9	1343.9±278.6	299.7±195.0	1.15±0.13
	125≤	6	130.6±15.6	1351.6±460.0	306.3±217.7	1.15±0.14
Phosphorus	<75	-	-	-	-	-
	75~125	22	141.7±17.9	1209.5±235.0	306.2±209.6	1.19±0.16
	125≤	38	136.7±15.9	1311.2±295.5	318.2±192.8	1.15±0.13
Iron	<75	14	140.4±13.4	1239.1±284.2	311.3±232.4	1.14±0.19
	75~125	33	137.9±19.6	1275.4±267.7	322.3±177.9	1.17±0.13
	125≤	13	137.7±9.6	1324.8±324.3	296.2±214.8	1.18±0.13

[1)]Mean±standard deviation. [2)]No subject.
[3)]Means with different superscripts within a column are significantly different at α=0.05 as determined by Duncan's multiple range test.

Table 6. Antioxidant enzyme activities by dietary intake categorized by food group

Food groups	Intake (g/3 days)	n	Age (yrs)	SOD (U/mL)	GPx (U/mL)	CAT (kU/L)	TA (mmol/L)
Fruits	<100	11	69.3±5.8[a]	135.2±29.4[1)]	1090.2±267.8	213.1±127.9	1.14±0.08[b2)]
	100~200	12	66.4±8.1[ab]	143.5±23.1	1009.1±214.1	283.1±199.8	1.16±0.06[ba]
	200<	37	63.3±7.7[b]	141.9±27.2	1171.9±244.9	264.6±149.2	1.20±0.08[a]
Eggs	<25	30	64.5±8.1	140.6±29.4	1115.5±218.7	252.4±157.5	1.19±0.09
	25~50	12	64.3±6.9	143.0±25.6	1078.3±303.4	273.9±131.4	1.19±0.11
	50<	18	66.4±7.9	140.1±24.0	1183.3±260.4	257.9±172.7	1.17±0.06
Soy foods	<100	19	63.5±7.7	139.7±23.7	1145.8±227.3	315.0±180.3	1.20±0.09
	100~200	25	64.8±8.0	145.0±32.5	1115.8±277.8	235.1±133.1	1.17±0.08
	200<	16	67.1±7.3	135.2±18.5	1126.8±239.5	226.4±144.3	1.18±0.06
Milk	<100	35	65.9±7.6	146.0±28.3	1102.2±250.6	260.5±133.0	1.19±0.09
	100~200	10	65.0±8.5	142.6±27.3	1063.7±250.7	233.3±189.5	1.17±0.08
	200<	32	63.0±7.7	124.5±12.1	1266.5±205.4	270.6±185.0	1.18±0.08
Vegetable	<500	12	66.8±8.5	144.3±29.1	1137.9±218.3	268.6±146.6	1.20±0.05[ba]
	500~1,000	32	64.2±8.0	134.5±21.7	1154.6±235.5	244.5±163.5	1.16±0.08[b]
	1,000<	16	65.4±6.8	147.7±30.7	1082.1±293.6	277.8±151.4	1.21±0.09[a]

[1)]Mean±standard deviation.
[2)]Means with different superscripts within a column are significantly different at α=0.05 as determined by Duncan's multiple range test.

than 200 g of fruit were significantly higher, 1.20 mmol/L, compared with subjects who consumed under 100 g, 1.14 mmol/L ($p<0.05$). TA of subjects who took more than 1,000 g of vegetables were higher at 1.21 mmol/L, compared with subjects who consumed under 100 g and those consumed 100~200 g at 1.20 mmol/L and 1.16 mmol/L, respectively ($p<0.05$). These results indicate that a higher intake of fruits and vegetables rich in vitamin C, an antioxidant nutrient, results in higher antioxidant activity. In a study by Nantz et al. (37), subjects were divided into a control group, and two test groups given either fruit or a vegetable juice powder capsule for 77 days. The fruit group and a vegetable juice power capsule group exhibited 50% higher blood levels of vitamin C and oxygen radical absorptive capacity. Lunet maintained that anxioxidant vitamins could repress the development of gastric cancer, explaining that there is an inverse relationship between the intake of fruits and vegetables and the incidence of gastric cancer (38). Chattopadhyay & Bandyopadhyay (39) maintained that the intake of fruit and vegetable and regular exercise directly prevented ischemic heart disease. There was no significant difference in antioxidant enzyme activity according to intake levels of eggs, soybeans and milk products. Lee reported that genistein and soy protein prevented diabetic complications and lowered hyperglycemia in streptozotocin-induced diabetic rat by reducing hepatic superoxide dismutase, catalase and glutathione peroxidase activities (40). Liu's study reported that milk-kefir and soymilk-kefir prevented mutagenic and oxidative demage (41). The groups consuming soy food showed the lowest antioxidant activity levels in the youngest group of subjects (50's) and the highest level in 60's and 70's. But antioxidant capacity is subject to age as shown the highest level in 50's. It is difficulty to evaluate the effects of antioxidant capacity by the intake of soy food. The results will vary on the intake level of soy food by an age group. The recommended intake of soy food should be studied based on this finding.

CONCLUSION

In summary, the lower BMI was, the lower activity in SOD of postmenopausal women. The more fruits and vegetables were consumed, the higher the TA. With excessive intake of protein and niacin, the activity of SOD and TA was rather low. SOD and TA among antioxidant indexes seemed to be mostly influenced by exogenous factors. Therefore, studies on the effects of nutrition intake on antioxidant enzyme activity should be conducted.

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