Daily Nutritional Intake and Serum Levels of Lipoprotein, Cholesterol and Protein

—A Study of Buddhist Nuns*—

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=國文抄錄=

韓國女僧의 營養攝取와 血淸 Lipoprotein, Cholesterol 및 蛋白量의 關係

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長期的인 榮食攝取가 血淸의 lipoprotein, cholesterol 및 蛋白量에 미치는 影響을 알아보기 위하여 젊은 女僧 45名(20~35세)과 對照群으로 女大生 29名(20~22세)을 硏究對象으로 하였다. 하루 熱量攝取는 女僧들이 1,945 kcal였고 女大生은 1,815 kcal였다. 熱量構成比率은 女僧들이 炭水化物 : 蛋白質 : 脂肪=84 : 11 : 5였고 學生은 70 : 15 : 15였으며 이는 女僧들의 炭水化物 偏重 및 脂肪攝取不足을 보여준다. 身體計測結果 女僧들은 女大生보다 身長을 除外하고, 體重, 脂肪層두께, 體表面積 및 肥滿度係數가 모두 높았다. 收縮期 및 弛緩期血壓은 女僧과 女大生이 거의 같았다.

血淸의 總脂肪, cholesterol 및 蛋白量은 女僧과 女大生間에 有意한 差異가 없었다. 그러나 電氣泳動으로 分劃하여 血淸의 high density lipoprotein(HDL), very low density lipoprotein(VLDL) 및 low density lipoprotein(LDL)量을 比較해 본 結果, 女僧들의 HDL은 女大生보다 낮았으나 LDL은 有意하게 높았다. Cholesterol 分劃結果도 역시 女僧들의 HDL-cholesterol 값은 女大生보다 有意하게 낮은 反面 LDL-cholesterol은 有意하게 높았다. Lipoprotein과 cholesterol 間의 相關係數(r)를 計算한 結果 LDL과 LDL-cholesterol(r=0.40), VLDL과 VLDL-cholesterol(r=0.85), HDL과 HDL-cholesterol(r=0.45), 血淸總脂肪量과 cholesterol(r=0.66) 및 血淸 總 cholesterol과 LDL-cholesterol(r=0.79) 間에는 有意한 相關關係를 보여주었다. 그러나 血淸 cholesterol과 飮食攝取 및 身體計測結果間에는 有意한 相關關係가 나타나지 않았다. 血淸蛋白量은 女僧과 女大生間에 差異가 없었다.

以上의 結果는 女僧들의 長期的인 榮食攝取로 因해 人體의 lipoprotein 및 cholesterol 代謝에 影響이 있음을 示唆해 주고 있다.

INTRODUCTION

Cholesterol is a steroid widely distributed throughout the body and serves as a precursor of other steroids, bile acids, sex hormones and adrenocortical hormones[1]. Cholesterol is not only absorbed from the gastrointestinal tract but also synthesized in the cells of the body. Cholesterol and other lipids are transported in blood by lipoproteins which are classified into 4 classes on the basis of their density: chylomicrons, very low density lipoprotein (VLDL), intermediate-density lipoprotein(IDL), low density lipoprotein(LDL), and high density lipoprotein(HDL)[2].

Elevated plasma cholesterol level has been identified as a major risk factor for atherosclerosis which has been one of the most important medical problems[3~6]. Plasma total cholesterol and LDL-

* Supported by Research Grant(1981) from the Korean Traders Scholarship Foundation, Seoul, Korea.

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cholesterol concentrations are closely associated with cornary heart disease and related disease, and plasma HDL-cholesterol level is associated with reduced risk of coronary artery disease[7~9]. Many studies have reported that differences in habitual diet pattern are associated with differences in group mean cholesterol and coronary heart disease incidences[10~12].

Comparing pure vegetarians with lacto-ovo-vegetarians and omnivores, the serum cholesterol level was highest in omnivores and lowest in pure vegetarians[13~15]. Not only serum total cholesterol level but also LDL-cholesterol and VLDL-cholesterol level of the vegetarians were markedly lower than the control group. In 1959, two groups of Korean investigators reported on the serum lipid levels of different population groups of Koreans[16,17]. Both studies observed a direct correlation between the dietary fat intake and serum cholesterol levels. The Korean taking high fat and high caloric American diet in the US army had significantly higher serum cholesterol levels. Besides, Buddhist monks have been reported to have low serum cholesterol level[16].

The present study concerns primarily serum lipoproteins, cholesterols and protein in a young female group of pure vegetarians, Buddhist nuns at the Unmoon-sa Temple.

MATERIALS AND METHODS

The Korean Bhiksuni(Buddhist nun: BN) at the Unmoon-sa Temple in Kyungpook Province and female nursing students staying in the dormitory at Kyungpook Medical School were studied in Fall, 1981. Among approximately 150 BN in the temple, 45 volunteers aged 20 to 34 years who had been nuns over 5 years were studied. In the temple, no animal products except milk were allowed and this dietary regulation had been kept very strictly.

Participants provided detailed medical and social histories. Weight, height and skin-fold thickness at the back of the left arm and supra-iliac areas were measured. In order to minimize the variations in measurement, one trained technician measured the skin-fold thickness of the subjects standing in a relaxed condition with a caliper. Resting blood pressure was determined by the standard arm cuff procedure with a sphygmomanometer while the subject remained seated. Body surface area(BSA) and obesity index were calculated as follows:

$$BSA = Weight(kg)^{0.425} \times Height(cm)^{0.725} \times 0.00718$$

$$\text{Obesity Index} = \frac{Weight(kg)}{0.56 \times Height(cm) - 38}$$

Average dietary intake of each subject was obtained by a detailed 24-hr dietary recall interview conducted for 2 days. Samples of premeasured foods and serving utensils were used to illustrate portion sizes. Food composition table developed by the Korean branch of FAO[18] was used to calculate the contents of carbohydrate, protein and lipid, and their caloric values in the diet.

After an overnight fast for 12 hrs, 10 ml of venous blood was drawn. One ml of blood was stored in a bottle with dried double oxalate for the measurement of hematocrit and hemoglobin values, and serum from the rest of the blood was separated and then frozen at −60°C for the measurement of protein, lipid and cholesterol levels. Serum total-cholesterol was measured enzymatically with a kit manufactured by Iatron Company, Japan. Serum total lipid was measured with the sulfo-phosphio-vanillin method[19]. Serum total protein was measured by the method of Lowry et al[20]. Fractions of serum protein, lipoproteins and cholesterols were analyzed by Helena electrophoresis system. Hematocrit and hemoglobin levels of the blood were measured with microcapillary and cyanmethemoglobin methods, respectively.

Comparisons using the appropriate students' t-test were made to determine if significant differences existed within different age groups of the BN or between the BN and female students. Simple regression analysis was made to find out correlation among serum cholesterol and lipoprotein levels, physical characteristics and dietary intakes.

RESULTS

Daily caloric intake was 1,947 kcal for the BN and 1,815 kcal for the students(Table 1). The ratio of% calories of carbohydrate: protein: lipid from total calories in the BN was 85:11:5, and that in the students was 70:15:15(Table 1, Fig. 1 and 2).

Anthropometric measurements(Table 2) indicate that BN were significantly shorter and more obese than tne students($p<0.01$). Each age group of the BN showed no difference in physical measurements. The BN were 4 cm shorter but 5 kg heavier than the students. Thus, the body surface area, skin-fold thicknesses, and index of obesity of the BN were significantly higher than those of the students ($p<0.01$).

Serum total lipid level(Table 3 and Fig. 3) of the BN was not significantly different from that of the students, although the level tend to decrease in the older BN group. The BN showed different distribution of lipoprotein fractions from the students. The ratio of lipoprotein fractions of HDL: VLDL: LDL for the BN was 31:23:50, and the ratio for the students was 34:25:41. BN had lower HDL but significantly higher LDL fraction than the students. But VLDL level was similar in two groups.

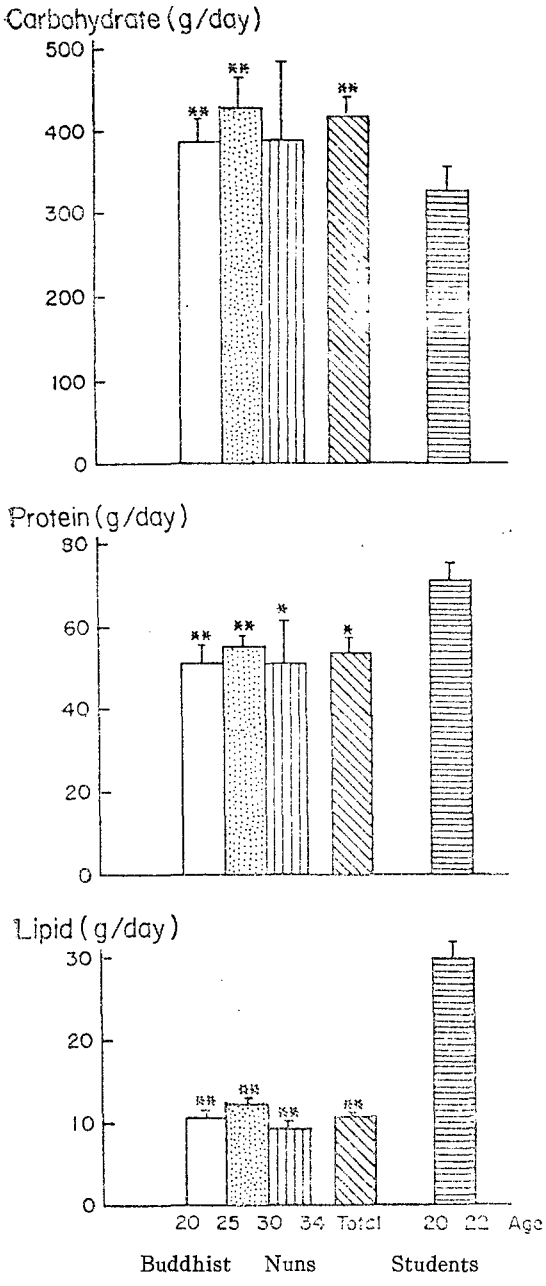

Fig. 1. Daily nutritional intakes of Buddhist nuns and students.

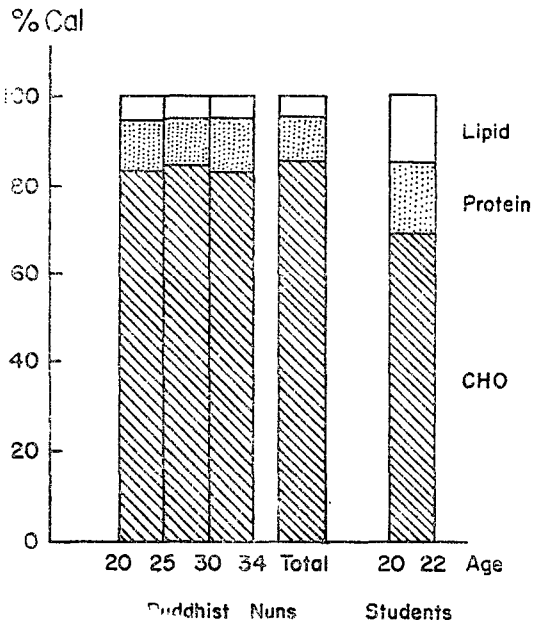

Fig. 2. Percent caloric intake from lipid, protein and carbohydrate in Buddhist nuns and students.

Table 1. Daily nutritional intake of Buddhist nuns and female students

	Buddhist Nuns				Students
Age:	20~24	25~29	30~34	Total	20~22
Energy Intake, Kcal/day	1,837±77.3	2,024±140.2*	1,824±308.8	1,947±93.9	1,815±169.5
Carbohydrate, g/day	389.0±26.4**	429.6±32.2**	387.4±94.9	415.0±25.3**	328.8±27.8
Protein, g/day	51.8±4.1**	54.5±4.2**	51.3±9.7*	53.7±3.1*	71.2±3.2
Lipid, g/day	10.7±1.5**	12.2±1.6**	9.2±0.9**	10.6±1.2**	29.8±3.9
Carbohydrate, %cal	83.6±5.6**	84.2±2.7**	84.7±2.9**	84.1±3.7**	69.6±3.1
Protein, %cal	11.2±0.8*	10.8±0.2*	11.2±0.8*	11.0±1.8**	15.6±2.6
Lipid, %cal	5.2±1.2**	5.0±0.7**	4.5±1.2**	4.9±0.8**	14.8±1.2
(n)	19	19	7	45	29

Values are Mean±S.E.
* $p<0.05$, ** $p<0.01$, Buddhist nuns vs. students.

Table 2. The blood pressure and anthropometric measurements in Buddhist nuns and female students

	Buddhist Nuns				Students
Age:	20~24	25~29	30~34	Total	20~22
Systolic Pressure, mmHg	104.0±2.32	105.8±2.11	103.3±3.64	104.8±1.42	103.5±2.11
Diastolic Pressure, mmHg	70.0±1.87	70.8±1.46	66.7±4.36	69.8±1.22	70.4±1.92
Heart Rate, beat/min	72.9±1.66	73.8±1.58	71.2±1.95	73.0±1.00	73.7±1.46
Height, cm	152±0.69	155±1.38**	153±1.89	154±0.75**	158±0.76
Weight, kg	51.9±0.94**	55.0±1.58**	52.1±2.00*	53.4±0.88**	48.5±0.55
Body Surface Area, m^2	1.47±0.02*	1.52±0.03**	1.47±0.03	1.47±0.03**	1.17±0.11
Skin-Fold Thickness:					
Back Arm, cm	1.52±0.16	1.55±0.17	1.46±0.20	1.51±0.04	1.53±0.06
Supra-iliac, cm	1.26±0.14**	1.33±0.16**	1.22±0.27**	1.28±0.01**	0.92±0.06
Obesity Index	1.10±0.01**	1.12±0.03**	1.09±0.04**	1.11±0.02**	0.94±0.07
(n)	19	19	7	45	29

Values are Mean±S.E.
* $p<0.05$, ** $p<0.01$, Buddhist nuns vs. students.

Table 3. Serum lipoproteins obtained after electrophoresis in Buddhist nuns and female students

	Buddhist Nuns				Students
Age:	20~24	25~29	30~34	Total	20~22
Total Lipid, mg/dl	584.0±40.2	517.1±16.5	465.0±50.2	530.5±18.3	527.2±13.8
% of Lipoproteins Fractions					
HDL	30.2±3.2	28.7±2.5*	36.1±3.6	31.3±1.6	34.3±1.0
VLDL	22.1±2.0	23.9±1.9	21.8±2.2	22.9±1.2	24.7±1.1
LDL	51.0±3.9**	50.7±3.2**	44.9±2.7**	49.8±2.0**	40.8±1.5
Conc. of Lipoprotein Fractions, mg/dl					
HDL	176.9±16.7	146.6±12.9*	161.8±16.5	163.4±7.9	178.8±5.2
VLDL	128.9±15.3	125.5±11.8	102.4±18.9	120.2±8.1	130.4±7.4
LDL	303.9±36.5**	261.2±19.3**	213.6±33.1	266.9±16.4**	217.1±11.3
(n)	15	21	9	45	29

Values are Mean±S.E.
* $p<0.05$, ** $p<0.01$, Buddhist nuns vs. students.
HDL: High density lipoprotein, VLDL: Very low density lipoprotein, LDL: Low density lipoprotein.

Table 4. Serum cholesterols obtained after electrophoresis in Buddhist nuns and female students

	Buddhist Nuns				Students
Age:	20~24	25~29	30~34	Total	20~22
Total Cholesterol, mg/dl	163.9±7.6	153.7±6.1	154.0±12.0	157.2±4.3	166.3±5.3
% of Cholesterol Fractions					
HDL-Chol.	29.4±2.5**	29.9±1.6**	29.6±2.6**	29.7±1.2**	39.9±1.8
VLDL-Chol.	12.9±1.2	13.3±1.5	11.7±1.2	12.9±0.8	12.8±1.3
LDL-Chol.	61.2±3.5*	60.6±2.1**	61.6±2.2**	61.0±1.5**	52.2±1.8
Conc. of Chol. Fractions, mg/dl					
HDL-Chol.	47.4±3.6**	45.7±3.0**	44.3±3.6**	46.0±1.9**	66.0±3.5
VLDL-Chol.	20.5±2.3	20.9±2.8	19.1±3.1	20.5±1.6	21.5±2.4
LDL-Chol.	101.5±8.2**	93.1±5.2**	95.4±9.5**	96.4±3.6*	87.2±3.1
Ratio: Total Chol/HDL-Chol.	3.7±0.2**	3.6±0.3**	3.6±0.5*	3.6±0.2**	2.6±0.1
Ratio: LDL-Chol/HDL-Chol.	2.3±0.2**	2.2±0.2**	2.3±0.4*	2.3±0.1**	1.4±0.1
(n)	15	21	9	45	29

Values are Mean±S.E.
* $p<0.05$, ** $p<0.01$, Buddhist nuns vs. students.
HDL: High density lipoprptein, VLDL: Very low density lipoprotein, LDL: Low density lipopration, Chol.: Cholesterol, Conc.: Concentration.

Table 5. Serum proteins obtained after electrophoresis in Buddhist nuns and female students

	Buddhist Nuns				Students
Age:	20~24	25~29	30~34	Total	20~22
Total Protein, g/dl	7.4±0.12	7.0±0.09	7.0±0.19	7.1±0.01	7.5±0.08
% of Protein Fractions					
Albumin	54.8±0.83	56.3±0.66	55.7±1.65	55.6±0.54	54.1±0.66
Globulin: α_1	2.9±0.23	3.3±0.20	2.7±0.25	3.0±0.13	3.1±0.17
α_2	10.0±0.46	9.2±0.31	9.5±0.41	9.6±0.24	10.2±0.27
β	12.6±0.40*	12.3±0.36**	13.0±0.96	12.6±0.29**	13.9±0.26
γ	19.7±0.84	18.9±0.68	18.9±1.06	19.3±0.47	19.1±0.50
Conc. of Protein Fractions, g/dl					
Albumin	1.04±0.08	3.92±0.06	3.82±0.14	3.95±0.05	4.04±0.04
Globulin: α_1	0.21±0.02	0.22±0.01	0.71±0.02	0.21±0.01	0.23±0.01
α_2	0.71±0.03	0.61±0.03	0.61±0.06	0.68±0.02	0.76±0.02
β	0.90±0.03**	0.82±0.04**	0.82±0.11	0.90±0.02**	1.05±0.03
γ	1.41±0.07	1.25±0.06*	1.22±0.12	1.37±0.04	1.44±0.05
A/G Ratio	1.22±0.04	1.30±0.03	1.28±0.09	1.26±0.03	1.19±0.03
Hematocrit, %	39.5±0.73	39.9±0.47	40.2±0.91	39.8±0.36	39.9±0.44
Hemoglobin, g/dl	12.5±0.24	12.7±0.13	12.6±0.20	12.6±0.11	12.1±0.11
(n)	15	21	9	45	29

Values are Mean±S.E.
* $p<0.05$, ** $p<0.01$, Buddhist nuns vs. student.
A/G ratio: Serum albumin to globulin ratio.

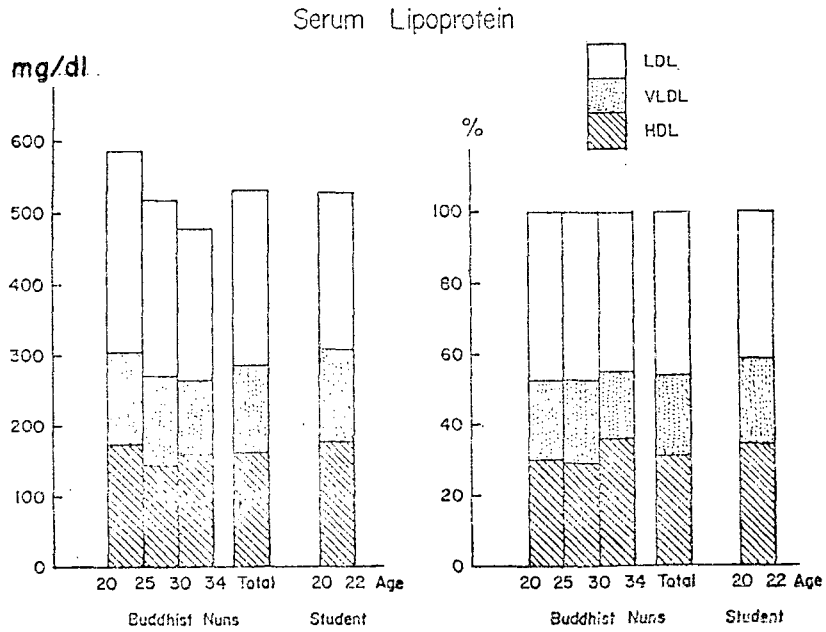

Fig. 3. Serum lipoproteins obtained after electrophoresis in healthy young Buddhist nuns and students.

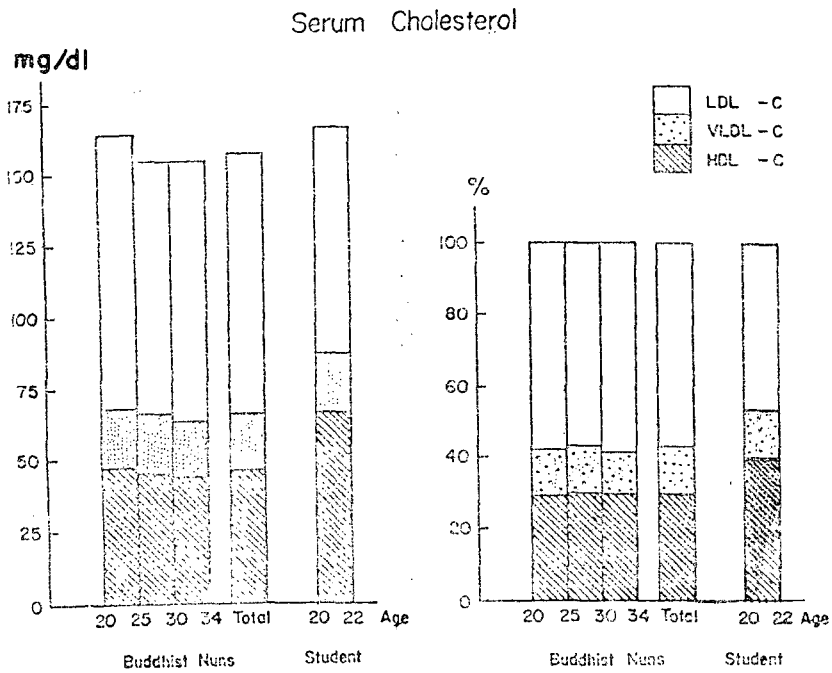

Fig. 4. Serum cholesterols obtained after electrophoresis in healthy young Buddhist nuns and students.

Serum total cholesterol level (Table 4 and Fig. 4) of the BN (157±4 mg/dl) was slightly lower than that of the students (166±5 mg/dl), but was not significantly different. However, the BN and students showed clear difference in HLD-and LDL-cholesterol levels. Each age group of the BN showed no

Table 6. Correlation coefficeints among serum cholesterols and serum lipoproteins in buddhist nuns(BN) and female students(St)

	Lipoproteins							
	Total Lipid		HDL		VLDL		LDL	
	BN	St	BN	St	BN	St	BN	St
Serum Protein	0.40	0.05	0.09	0.28	−0.10	−0.08	−0.012	−0.15
Total Lipid	1.0	1.0	−0.038	−0.37	0.26	0.04	0.08	0.32
HDL	—	—	1.0	1.0	−0.36*	−0.07	−0.17	−0.22
VLDL	—	—	—	—	1.0	1.0	−0.64**	−0.72**
LDL	—	—	—	—	—	—	1.0	1.0
Total Chol.	—	—	—	—	—	—	—	—
HDL-Chol.	—	—	—	—	—	—	—	—
VLDL-Chol.	—	—	—	—	—	—	—	—
LDL-Chol.	—	—	—	—	—	—	—	—

	Cholesterol							
	Total Chol.		HDL-Chol.		VLDL-Chol.		LDL-Chol.	
	BN	St	BN	St	BN	St	BN	St
Serum Protein	0.54**	0.001	0.04	−0.22	0.01	−0.46	−0.04	0.60
Total Lipid	0.66**	0.68*	0.38**	−0.19	0.34*	0.33*	−0.02	−0.04
HDL	−0.16	−0.30	0.45**	0.43**	−0.53	−0.64	0.09	0.06
VLDL	0.08	−0.36	0.48	−0.10	0.85**	0.45**	−0.17	−0.19
LDL	0.09	0.49	0.08	−0.19	−0.18	0.16	0.40**	0.48**
Total Chol.	1.0	1.0	0.23	0.13	0.19	0.06	0.79**	0.73**
HDL-Chol.	—	—	1.0	1.0	0.26	−0.43	−0.05	−0.16
VLDL-Chol.	—	—	—	—	1.0	1.0	−0.63**	−0.34
LDL-Chol.	—	—	—	—	—	—	1.0	1.0

* $p<0.05$, ** $p<0.01$.
Chol.: Cholesterol, HDL: High density lipoprotein, VLDL: Very low density lipoprotein, LDL: Low density lipoprotein.

difference in each cholesterol level. The ratio of the cholesterol fractions in HDL: VLDL: LDL for the BN was 30:13:61, whereas the ratio for the students was 40:13:52. BN had significantly lower level of HDL-cholesterol($p<0.01$) than the students. However, the VLDL-cholesterol level of the BN was not different from that of the students.

Linear regression analysis among the serum cholesterols and lipoproteins is summarized in Table 6. There were positive correlations between serum total lipid and total cholesterol($r=0.66$, $p<0.01$, Fig. 6), serum total cholesterol and LDL-cholesterol ($r=0.79$, $p<0.01$, Fig. 7), LDL and LDL-cholesterol ($r=0.40$, $p<0.01$), VLDL and VLDL-cholesterol ($r=0.85$, $p<0.01$), HDL and HDL-cholesterol($r=0.45$, $p<0.01$). However, linear regression analysis of the serum cholesterol fractions on anthropometric measurements and dietary intakes(Table 7) did not reveal any consistantly meaningful correlations.

Serum total protein value(Table 5 and Fig. 5) was similar in the BN(7.1 ± 0.01mg/dl) and the students (7.5 ± 0.08 mg/dl). Percent of each serum protein fraction for the BN and students was very similar and independent on the total protein levels. Percent serum albumin, α_1-, α_2-, β-, and γ-globulins of

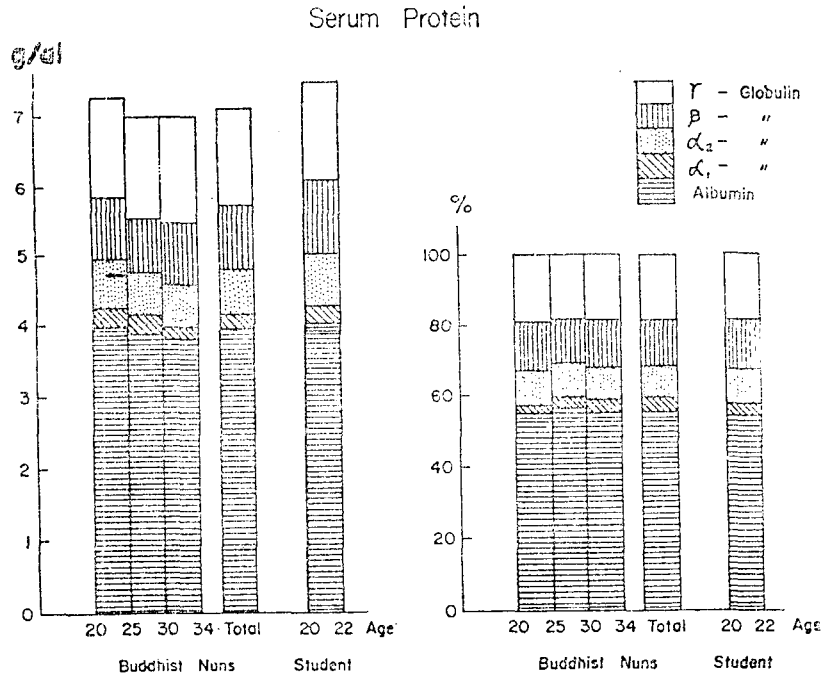

Fig. 5. Serum proteins obtained afterel ectrophoresis in Buddhist nuns and female students.

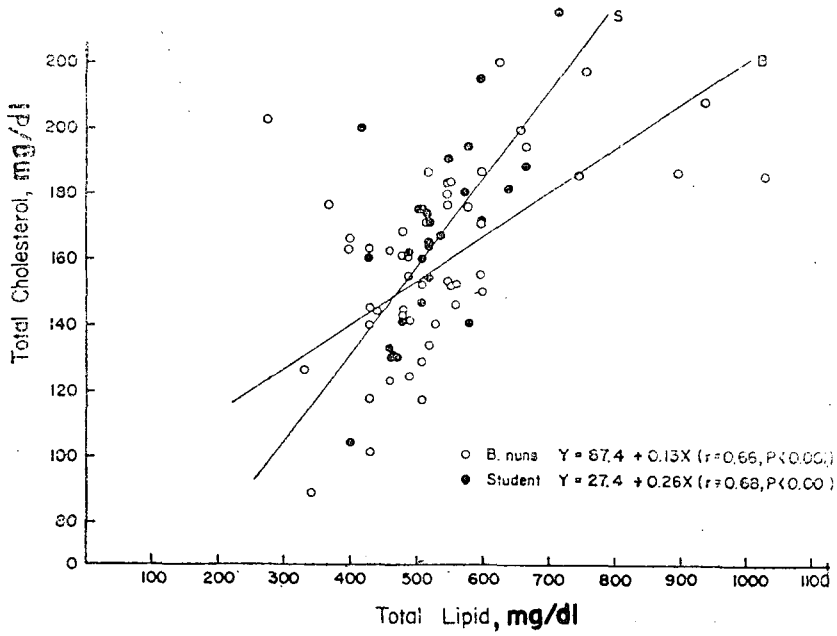

Fig. 6. The correlation between the total serum lipid and total serum cholesterol in Buddhist nuns and female students.

Table 7. Correlation coefficients between serum cholesterol levels and physical characteristics and dietary intakes in buddhist nuns(BN) and female student(St)

	Cholesterol							
	Total		HDL		VLDL		LDL	
	BN	St	BN	St	BN	St	BN	St
Skin-Fold Thickness: S_1	0.13	0.30*	−0.08	−0.18	0.13	−0.26	0.09	0.17
S_2	0.24	0.01	−0.10	−0.43**	0.15	0.12	0.29*	0.38*
Obesity Index	0.05	−0.35*	−0.13	−0.24	−0.12	−0.21	0.40**	−0.10
Body Surface Area	0.49**	−0.34*	0.22	−0.21	0.32**	−0.22	0.20	−0.09
Calorie Intake	−0.07	−0.36*	−0.04	−0.35*	0.04	−0.21	−0.17	0.08
Protein Intake	0.16	0.14	−0.07	0.20	0.15	0.17	0.11	−0.26
Carbohydrate Intake	−0.16	−0.41	0.01	−0.39*	−0.40**	−0.23	−0.23	0.05
Fat Intake	−0.21	−0.28	−0.15	−0.26	−0.11	−0.20	−0.08	0.11

* $p<0.05$, ** $p<0.01$
S_1: at the triceps, S_2: at the supra-iliac.

Table 8. Comparison of serum cholesterol levels of several reported vegetarians

	Serum Cholesterol							
	mg%	Precent			mg%			
	Total-C	HDL-C	VLDL-C	LDL-C	HDL-C	VLDL-C	LDL-C	Ref.
Buddhist nun*	164	29.4	12.9	61.2	47.4	20.5	101.5	
Students(F)*	166	39.9	12.8	52.2	66.0	21.5	87.2	
Korean	124	21.4	—	78.6	26.5	—	97.2	17
Koreans taking US meal	184	24.2	—	73.6	44.5	—	135.3	
US soldier	207	22.7	—	77.3	47.0	—	159.8	
Buddhist monk	124	—	—	—	—	—	—	16
Korean	137	—	—	—	—	—	—	
Koreans taking US meal	182	—	—	—	—	—	—	
US soldier	194	—	—	—	—	—	—	
Vegetarians	126	33.3	9.4	57.9	42.0	11.8	73	15
Control	184	26.6	9.3	64.1	49.0	17.2	118	
High CHO diet	123	26.0	12.2	61.8	32.0	15.0	76	20
Control	154	27.9	5.8	66.2	43.0	9.0	102	
7th-day Adventist	160	—	—	—	—	—	—	14
NY City(F)	200	—	—	—	—	—	—	

CHO: Carbohydrate, F: female, Ref.: reference.
* Authors' present study

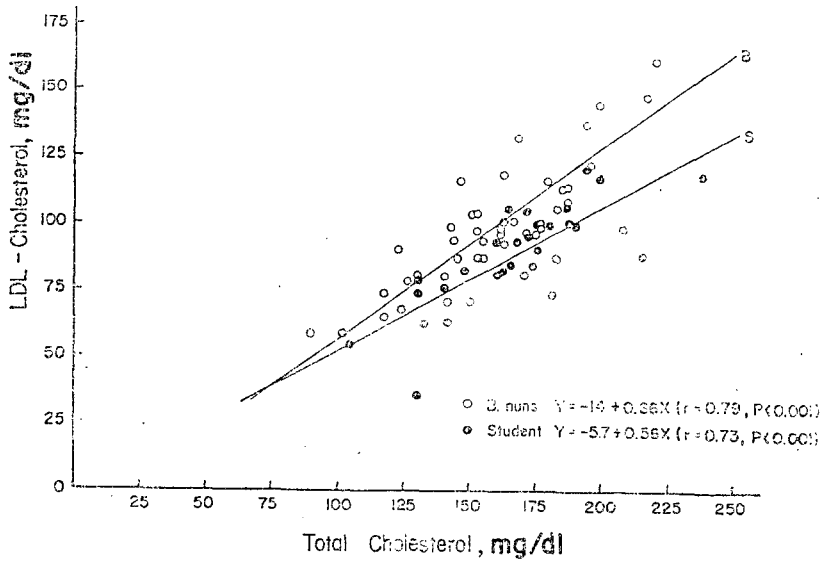

Fig. 7. The correlation between the total serum cholesterol and LDL-cholesterol in young Buddhist nuns and female students.

serum total protein in each group was approximately 55:3:10:13:19. The ratio of serum albumin to globulin was 1.26 for the BN and 1.19 for the students. The BN and the students showed the similar values of hematocrit(40%) and hemoglobin concentration(12mg/dl).

DISCUSSION

In this investigation the serum levels of total lipid, cholesterol and protein of the young BN were not significantly different from the young female students. However, the proportion of HDL-cholesterol from the serum total cholesterol was significantly lower and that of LDL-cholesterol was significantly greater in the BN than in the controls. Many studies have reported low mean levels of serum lipids among populations consuming a predominantly vegetarian diet[14~17,21]. Serum cholesterol of other reports and the present result are compared in the table 8. Two Korean reports in 1959[16,17] showed that the serum total cholesterol levels for general population of Koreans and Buddhist monks were markedly lower than Koreans taking American food in the US army or among US soldiers. Since the dietary staples of Koreans in early 1950's were mainly grains and vegetables with little animal foods, their serum cholesterol level might have been low. On the other hand, Occidentals who took high carbohydrate diet for 5 days[21] and the vegetarians taking macrobiotic diets(high in complex carbohydrates and low in simple sugars) supplemented by dairy products, eggs and fishes[15], had the serum cholesterol level as Koreans in 1959[16~17]. However, female lacto-ovo-vegetarians of Seventh-day Adventists[14] showed serum cholesterol level of approximately 160mg/dl which was higher than other vegetarian levels but was similar to the levels of the present study. To lower the total serum cholesterol by dietary manipulation in the Seventh-day Adventists, fat substitution (increasing poly-unsaturated fatty acid intake) was more effective than fat restriction[14]. This suggests that the kind of fat intake is more important in determining the serum total cholesterol level than the amount of fat intake. This result has received substantial support from other numerous studies[6,22~25]. The reasons why serum total cholesterol

level of the BN was higher than that of most other vegetarians and why the levels of BN and students are similar are not clear at this moment, but they could be speculated as follows. First of all, the range of serum cholesterol level of different populations of vegetarians is wide. Secondly, the diet supplied to the students at the dormitory in the present study was close to the lacto-ovo-vegetarian diet with little animal foods. Dietary intake affects not only total serum lipid levels but also proportions of lipoprotein and cholesterol fractions and apoproteins[15,21]. Chronic dietary intake of high carbohydrate and low fat in the BN lowered percents of HDL and HDL-cholesterol, elevated percents of LDL and LDL-cholesterol and did not alter the percents of VLDL and VLDL-cholesterol from the total serum levels. The present study encompasses the BN who were taking that particular diet over 5 years(average 7 years). On the other hand, intakes of high carbohydrate diet for 4~5 days increased the serum VLDL-cholesterol but decreased the LDL-and HDL-cholesterol in man[21]. However, the percent LDL-and HDL-cholesterol from the total cholesterol level was not changed. The most striking acute effects of high carbohydrate diet were increased VLDL and triglyceride levels and altered apoprotein compositions of all lipoproteins. Vegetarians taking macrobiotic diets for average of 3 years[15] showed higher %HDL-cholersterol and lower %LDL-cholesterol from the total cholesterol than controls in contrast to the present results of the BN. Although the vegetarian diet of macrobiotics was high in carbohydrate, serum concentrations of triglyceride and VLDL-cholesterol were not different from the control values[15] in contrast to the acute effect of high carbohydrate diet[21]. Disagreement in the results of different investigations is prboably due to differences in nutrient compositions of the diet, duration of that particular dietary intake, and nondietary factors affecting lipid metabolisms. However, it seems to be clear that dietary intake affects not only serum total levels of lipid, cholesterol and triglyceride but also the composition of each fraction of lipoprotein and cholesterol. Besides the dietary intake, HDL and HDL-cholesterol levels are affected by exercise[26,27], cigarette smoking[28], alcohol[29], and sex[27].

Since serum cholesterol and other lipids are combined with protein components(apolipoprotein or apoprotein) of the lipoproteins, lower concentration of HDL-cholesterol could be due to fewer HDL particles or particles with altered composition of apoproteins. Therefore, not only the lipid components but also apoprotein composition of the lipoprotein are important. For example, plasma level of HDL-cholesterol in insulin-dependent diabetics was normal or high, but their HDL composition was markedly different from the controls: significantly elevated apolipoprotein A-Ⅰ/A-Ⅱ ratio in diabetics[30]. Alterations in apoprotein composition were also reported in atherosclerotic cardiovascular diseases[31,32]. Therefore, it increasingly appears to be necessary to distinguish between alterations in HDL particle number and HDL particle composition to understand the dynamics of lipid metabolism.

Chronic intake of vegetarian diet of the BN apparently altered serum patterns of lipoprotein and cholesterol: higher levels of LDL and LDL-cholesterol, and lower levels of HDL and HDL-cholesterol than the controls. However, the above changes were not in agreement with the changes in other reported vegetarians[15,21]. In order to clarify the effects of vegetarian diets on lipid metabolism, it is necessary to analyze the nutrient compositions of each vegetarian diet, duration of the particular diet intake, and nondietary factors. Furthermore, it is necessary to analyze not only lipid components but also the protein components of the lipoproteins.

SUMMARY

To determine the influence of vegetarian diet on serum lipoprotein, cholesterol and protein levels, 45 young Buddhist nuns(age: 20~34 years) and 29 female students(age: 20~22 years) were examined. Daily caloric intakes were 1,945 Kcal for the Bud-

dhist nuns and 1,815 Kcal for the students. The ratio of% calorie of carbohydrate: protein: fat from total calories in the Buddhist nuns was 84: 11:5 and that in the students was 70:15:15. The Buddhist nuns had significantly higher carbohydrate intake but markedly lower lipid intakes than the students. Anthropometric measurement showed that the Buddhist nuns had significantly higher values of body weight, skin-fold thickness, body surface area and obesity index than the students. Both systolic and diastolic pressures of the Buddhist nuns and students were similar.

Serum levels of total lipid, cholesterol and proteins in the Buddhist nuns were not different from those of the students. However, when comparing the levels of high density lipoprotein(HDL), very low density lipoprotein(VLDL) and low density lipoprotein(LDL) fractions, the Buddhist nuns had lower level of HDL but significantly higher LDL levels than the students. Furthermore, the Buddhist nuns had significantly lower levels of serum HDL-cholesterol but significantly higher LDL-cholesterol levels. There were significant correlations between LDL and LDL cholesterol($r=0.40$), VLDL and VLDL-cholesterol($r=0.85$), HDL and HDL-cholesterol($r=0.45$), total serum lipid and total cholesterol ($r=0.66$) and total serum cholesterol and LDL-cholesterol($r=0.79$). On the other hand, values of both serum total protein, and fractions of serum proteins were similar in the Buddhist nuns and students(ratio of albumin: α_1-: α_2-: β-: and γ-globulins=55:3:10:13:19). Hematocrit and hemoglobin levels were similar in the Buddhist nuns and students.

Above results suggest that vegetarian diets of the Buddhist nuns produced alterations in the metabolism of the lipoproteins and cholesterol.

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