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☐ **Original Article** ☐

Evaluation of Dietary Risk Factors for Abnormal Serum Cholesterol in Korean Sedentary Male Adults

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ABSTRACT

This study investigated whether dietary factors are more influential factor than other health behavior such as drinking, smoking and exercise on abnormal serum cholesterol level inspite of Korean dietary pattern differences compared to Europeans and Americans.

A double case control study model has been used for the study design. One model consisted of high blood cholesterol cases and controls. The other model consisted of low blood cholesterol cases and controls.

5,938 sedentary male workers who had taken medical examinations at a university hospital were used as the study subjects. Out of the study subjects, 36 individuals with high blood cholesterol cases and 30 individuals with low blood cholesterol cases were selected. For the 66 individual control selection, the individual matching method was adopted.

The food frequency method was used to collect the data for assessment of the dietary factors. A standardized questionnaire was used to investigate other health behavior.

Logistic regression analysis was employed to measure the relative importance between the factors considered.

There were no statistically significant differences observed in nutrients consumption or other health behavior among the low, normal and high blood cholesterol groups. An overmatching effect had been suspected as the cause of those findings. However, the results of logistic regression analysis to identify the factors influencing high serum cholesterol showed that odd ratios of dietary factors such as tocopherol(3.0) and saturated fatty acid(1.6) were higher than 1. 1 of smoking and 1.2 of drinking. Similar results were also observed in cases of low serum cholesterol.

The above findings imply that although the dietary pattern is quite different from that of Europeans and Americans, the dietary factor is still a significant factor for abnormal blood cholesterol in Koreans. Therefore, the dietary risk factor identified in high fat consumption populations are still relevant for the relatively healthy Korean as a guideline for preventive health practices. (*Korean J Community Nutrition* 2(5) : 721~727, 1997)

KEY WORDS : dietary risk factor · serum cholesterol.

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Introduction

In the 1990s, malignant tumors, cerebrovascular disease and cardiovascular disease appear to have been the major cause of death in Korea(National Statistical Office 1991). According to the figures published by the Bureau of Statistics, the ischemic heart diseases mortality rate increased 6 times within a decade since the 1980s(National Statistical Office 1993).

Genetic factors as well as many others such as hypertension, diabetes mellitus, obesity, and individual health related behaviors are well known contributing factors in developing those disease(Kronmal et al. 1993 ; Sigfusson et al. 1991). Smoking, drinking, exercise and dietary factors have also been regarded as important health related behaviors(Jacques et al. 1991).

Hyperlipidemia such as high blood cholesterol and high blood triglyceride have been recognized as major risk factors for coronary artery disease(Sonoda 1992 ; Swahn & Vonschenck 1993). In particular, the importance of a high blood cholesterol level has been stressed by many researchers in relation to coronary artery disease. Hypercholesterolemia has been recognized as a major risk factor of not only coronary artery disease but also coronary heart disease (Arntzenius et al. 1985 ; Lipid Research Clinics Program 1984 ; National Education Cholesterol Program 1988). Every 1% reduction in serum cholesterol concentration reduces the risk of coronary events by about 1 – 2% in North American countries (Lipid Research Clinic Program 1984).

Diet in relation to fat consumption is of prime importance in the management of serum cholestrol for patients(Dwyer 1995) as well as for the general public in the U.S(Rimm et al. 1996), European countries(Fehily et al. 1993) and elsewhere(Report of a WHO Study group 1990). However, since dietary patterns including fat consumption are lower in Korea than Europe or America(Kim 1991 ; Lee et al. 1992 ; Oh & Lee 1995 ; Park et al. 1993 ; Park et al. 1993), the effect of dietary intake on serum cholesterol might be different from that of those countries. It may be presumed that the role of dietary factors is less significant on the serum cholesterol level than the other behavioral factors such as smoking, drinking, and exercise for Koreans compared to other countries. Therefore, this study investigated the relative importance of dietary factors, among other behavioral factors, on blood cholesterol using a double case control study model for Korean sedentary male adults. Cases were subjects with high or low blood cholesterol and controls were subjects with a normal range of serum cholesterol.

The relative importance between the factors considered was measured by an odd ratio from the result of the logistic regression analysis.

Materials and Method

1. Study subject

The study involved 5,938 sedentary male workers, mostly teachers and office clerks, who had taken routine medical examinations at the Wonkwang university hospital in 1995. Cases consisted of 36 persons with high serum cholesterol($>$240mg/dl) and 30 persons with low serum cholesterol($<$140mg/dl) out of the total study subjects. For the controls, 66 persons with normal serum cholesterol matched by age, blood pressure, and body mass index in each case were selected out of the same study subjects pool. Individual matching(MacMahon 1990) was intended in the control selection process to minimize the effect of aging, obesity and blood pressure on serum cholesterol.

2. Data Collection and processing

Dietary intake was measured by the food frequency method(Willet 1990). The food frequency questionnaire consisted of 93 food items including the 50 most commonly consumed foods in Korea(Korea Food Research Institute 1991). Pictures and food models were used to estimate portion size of the intake. Then the nutrient intake was calculated by the food composition table(The Office of Rural Development 1991) using an SAS computer program.

Health related behavior in terms of drinking, smoking and exercise were investgated using a standardiz-

ed questionnaire. Levels of the daily health behavior were measured by imposing 0 - 10 points, considering both the frequency and quantity of each episode.

After serum was separated it was kept in the storage with a temperature of −20 degrees until analyzed. The chemistry autoanalysis(Spectrum EPX, Abbott Co. U.S.A) was used to do lipid analysis. Total cholesterol(Alain 1974), TG(Buccolo 1974) and HDL cholesterol were measured by the enzymatic method. LDL cholesterol was taken as total cholesterol-HDL cholesterol-TG/5 by the Frierdwald calculating method(Frierwald 1972), and Lp(a), Apo A_1 and Apo B were measured by the immunological reaction with the Nephelometer(Behring Co. Germany).

3. Statistical analysis

Logistic regression analysis(Dixon et al. 1993) was employed to measure the relative importance between the factors. Categories of serum cholesterol level such as low cholesterol, high cholesterol and normal cholesterol were entered as the dependent variable.

Double case control models were analysed. One model consisted of high blood cholesterol cases and controls(normal cholesterol group). The other model consisted of low blood cholesterol cases and controls.

The odd ratio was calculated to estimate the relative importance of the variable as a risk factor.

Results and Discussion

1. General charecteristics of the study subjects

In preliminary analysis, there were no differences observed between the two control groups(normal cholesterol groups), one matched with the low serum cholesterol cases and another matched with the high serum cholesterol cases. Therefore data of the two normal cholesterol groups(control groups) has been combined in the following table 1, 2, 3, 4 and 5.

Mean age, height, weight, body mass index and blood pressure of the three groups(low, normal and high blood cholesterol group) are shown in Table 1. As expected there were no significant differences observed among the three groups in any of those variables since in the study design, variables such as age, obesity and blood pressure had been matched in the selection of individual controls.

2. Dietary intake

The nutrient intake of the three groups is shown in Table 2. In most of the nutrient intake, the high blood cholesterol group showed a tendency to consume more than both the normal and low blood cholesterol groups while the low cholesterol group tended to consume less than the normal and the high blood cholesterol group. But this tendency was not statistically significant in all the nutrients observed.

Cholesterol and fatty acid intake for the three groups were summarized in Table 3. Contrary to expectations, the cholesterol intake of the high cholesterol group was lower than that of the normal blood cholesterol group but the low blood cholestrol group showed the lowest cholesterol intake among the three groups. However, the tendency was not statistically significant. No differences were observed in the other fat related consumption such as total fatty acids, polyunsaturated fatty acid(PUFA),

Table 1. Mean age, height, weight, body mass index and blood pressure of the three groups at the different levels of serum cholesterol

Variables	Normal cholesterol group(n=66)	High cholesterol group(n=36)	Low cholesterol group(n=30)	F-value
Age(yrs)	46.09± 8.24	46.11±8.44	44.87±7.93	$0.26^{NS)}$
Height(cm)	166.11± 8.33	168.08±5.46	167.90±5.60	$1.19^{NS)}$
Weight(kg)	69.42± 8.01	70.61±7.58	69.60±8.22	$0.27^{NS)}$
BMI(kg/m^2)	25.36± 4.51	24.98±2.31	24.66±2.31	$0.42^{NS)}$
SBP(mmHg)	123.18±13.15	120.98±9.71	121.00±9.95	$0.84^{NS)}$
DBP(mmHg)	79.09± 7.59	76.97±7.11	77.00±9.15	$1.19^{NS)}$

Values are mean±S.D
NS : not significant
BMI(kg/m^2)=body mass index=weight(kg)/height(m^2)
SBP : systolic blood pressure
DBP : diastolic blood pressure

Table 2. Mean nutrients intake of the three groups at the different levels of serum cholesterol

Variables	Normal cholesterol groups(n=66)	High cholesterol group(n=36)	Low cholesterol group(n=30)	F-value
Energy(kcal)	1885.80±585.44	1934.61±576.23	1738.07±555.26	1.03$^{NS)}$
Protein(g)	77.95± 40.30	79.65± 31.36	68.09± 29.90	1.01$^{NS)}$
Fat(g)	36.00± 24.90	35.62± 17.73	32.29± 20.00	0.31$^{NS)}$
Carbohydrate(g)	314.84± 35.62	318.70±103.98	295.97± 78.17	0.70$^{NS)}$
Crude fiber(g)	6.02± 3.63	12.02± 32.32	4.92± 2.75	1.85$^{NS)}$
Calcium(mg)	649.58±327.56	708.87±376.10	593.61±361.91	0.90$^{NS)}$
Phosphorus(mg)	923.39± 39	973.81±536.59	793.15±481.22	0.90$^{NS)}$
Iron(mg)	16.26± 9.83	20.92± 23.68	13.93± 8.36	2.01$^{NS)}$
Sodium(mg)	322.70±298.08	314.33±182.48	265.57±252.49	0.51$^{NS)}$
Potassium(mg)	1344.30±957.46	1395.53±700.56	1095.27±595.14	1.27$^{NS)}$
Magnesium(mg)	38.76± 30.84	47.31± 55.72	31.77± 20.81	1.42$^{NS)}$
Retinol(RE)	37.18± 36.30	40.08± 30.07	36.63± 37.80	0.10$^{NS)}$
Thiamin(mg)	0.99± 0.49	0.97± 0.34	.87± 0.43	0.77$^{NS)}$
Riboflavin(mg)	1.07± 0.60	1.17± 1.01	0.95± 0.51	0.79$^{NS)}$
Niacin(mg)	13.66± 9.77	15.21± 9.17	11.30± 5.02	1.64$^{NS)}$
Ascorbic acid(mg)	79.07± 52.04	80.60± 49.19	59.34± 36.57	2.06$^{NS)}$
Tocopherol(mg)	3.05± 1.59	3.14± 1.20	2.63± 1.24	1.25$^{NS)}$

Values are mean ± S.D. NS : not significant

Table 3. Mean cholesterol and fatty acid intake of the three groups at the different levels of serum cholesterol

Variables	Normal cholesterol group(n=66)	High cholesterol group(n=36)	Low cholesterol group(n=30)	F-Value
Chol(mg)	175.34±82.0	157.98±26.95	148.95±54.76	0.31$^{NS)}$
PUFA(g)	4.32± 2.68	4.04± 1.94	3.53± 2.50	1.05$^{NS)}$
MUFA(g)	6.30± 4.28	5.96± 2.39	5.47± 3.65	0.52$^{NS)}$
SFA(g)	6.21± 3.98	6.21± 2.83	5.99± 3.40	0.04$^{NS)}$

Values are mean±S.D. NS : not significant
Chol : cholesterol PUFA : polyunsaturated fatty acid
MUFA : monounsaturated fatty acid SFA : saturated fatty acid

monounsaturated fatty acid(MUFA), and saturated fatty acid(SFA) in the three groups. Park et al.(1993) had similar findings from their study on the difference of intake in fat, total energy, carbohydrate, protein and fiber between the control group and the hypercholesterolemic patients.

3. Health behaviors

Health behavior in terms of drinking, smoking, and exercise of the three groups is shown in Table 4. Alcohol drinking and smoking levels of the high serum cholesterol group were higher than that of the normal and low serum cholesterol group. The exercise level of the high serum cholesterol group was lower than the normal and low serum cholesterol groups, and the low serum cholesterol group showed the highest exercise level among the three groups. But such a tendency was not statistically significant. It seems that the study subjects were quite homogeneous in term of their health behaviors regardless of their serum cholesterol levels since they were sedentary workers and participated in routine medical examinations at the university hospital.

4. Serum lipid and lipoprotein

Total cholesterol, HDL-cholesterol, LDL-cholesterol, triglyceride, Apo-A, Apo-B, Lp(a) of the three groups is shown in Table 5. These results were analysed by the analysis of a covariance model using food intake as a covariance variable.

As expected, total cholesterol and triglyceride were highest in the high serum cholesterol group. But

Table 4. Scores of drinking, smoking and exercise of the three groups at the different levels of serum cholesterol

Variables	Normal cholesterol group(n=66)	High cholesterol group(n=36)	Low cholesterol group(n=30)	F-value
Drinking	2.33±2.43	3.28±2.66	1.97±2.20	2.92$^{NS)}$
Smoking	2.70±3.39	4.11±3.89	3.17±3.74	1.79$^{NS)}$
Exercise	3.70±3.70	3.42±4.45	4.17±4.77	0.24$^{NS)}$

Values are mean±S.D. NS : not significant

Table 5. Concentration of serum lipid and lipoprotein of the three groups at the different levels of serum cholesterol

Variables	Normal cholesterol group(n=66)	High cholesterol group(n=36)	Low cholesterol group(n=30)	F-value
Total Chol(mg/dl)	188.71± 6.00	263.86± 21.18	121.90± 4.60	888.12***
TG(mg/dl)	177.95±119.96	224.24±117.03	14.96±53.03	7.83***
HDL-Chol(mg/dl)	41.82± 9.65	47.47± 16.25	39.48± 8.83	3.98*
LDL-Chol(mg/dl)	111.31± 26.82	171.58± 36.39	58.65±21.00	116.69***
VLDL-Chol(mg/dl)	35.59± 23.99	44.85± 23.41	22.99±10.61	7.83***
Apo $A\text{-}_1$(mg/dl)	138.57± 19.24	149.01± 22.61	122.18±23.41	12.67***
Apo B(mg/dl)	11.23± 13.54	155.12± 28.48	79.04±16.76	124.70***
Lp(a)(mg/dl)	11.92± 5.26	13.68± 5.80	8.78± 4.34	6.65**

Values are mean±S.D. *p<0.05 **p<0.01 ***p<0.001

contrary to expectations, the HDL-cholesterol level was highest in the high serum cholesterol group and lowest in the low serum cholesterol group. However, LDL-cholesterol was highest in the high serum cholesterol group and lowest in the low serum cholesterol group. Such a result may support the findings by Swahn & Vonschenck(1993) that LDL-cholesterol has more prognostic importance concerning high blood cholesterol than HDL-cholesterol. Such a fact might be more significant for the present study's subjects since they(selected cases and controls) are incredibly homogeneous in diet and other health related behaviors as observed already.

Apo-A, Apo-B, Lp(a) are highest in the high serum cholesterol group and the lowest in the low serum cholesterol group. This finding may indicate that those lipoprotein as well as LDL-cholesterol may predispose a subject to abnormal serum cholesterol levels.

5. Factors influencing high serum cholesterol groups

Results of the logistic regression analysis to identify the factors influencing high serum cholesterol are shown in Table 6. Dietary factors such as tocoperol (p=0.04) and monounsaturated fatty acid(p=0.08) consumption showed higher statistical significance than health behaviors such as smoking(p=0.09), drinking(p=0.11), exercise(p=0.61) on high serum cholesterol. The odd ratio as an indicator of risk factor has shown the same tendency. For example, the odd ratio of tocopherol, saturated fatty acid are 3.0 and 1.6 respectively which is higher than both the 1.1 of smoking and 1.2 of drinking.

The above findings imply that dietary factors are more important risk factor concerning high serum cholesterol for Korean(even though the statistical power is weak) than other health related behaviors such as smoking, drinking and exercise, inspite of their different dietary pattern from Europeans and Amerricans. Among the nutrient consumption factors, tocoperol was the most significant factor followed by saturated fatty acid consumption.

6. Factors influencing low serum cholesterol groups

Table 7 shows the results of the logistic regression analysis to identify the factors influencing low serum cholesterol. Cholesterol intake(p=0.09) is the second most probable factor followed by smoking(p=0.06) affecting low serum cholesterol other than drinking(p=0.15), and exercise(p=0.29). The finding may imply that dietary factors are more influential on low se-

Table 6. Logistic regression coefficient and odds ratio for the high cholesterol groups compared with normal cholesterol group

Selected variables	Parameter estimate	SE	Odd ratio	P
Energy	+0.0002	0.0017	0.0002	0.8879
Protein	−0.0213	0.0395	0.9789	0.5897
Fat	+0.0512	0.0503	1.0526	0.3085
Sodium	−0.0025	0.0027	0.9975	0.3515
Cholesterol	+0.0004	0.0004	1.0004	0.3604
SFA	+0.4510	0.4024	1.5698	0.2624
MUFA	−0.9920	0.5619	0.3708	0.0775
Tocopherol	+1.0907	0.5361	2.9746	0.0419
Smoking	+0.1225	0.0753	1.1191	0.1351
Drinking	+0.1614	0.1023	1.1752	0.1147
Exercise	−0.0296	0.0577	0.9708	0.6073

SFA : saturated fatty acid
MUFA : monounsaturated fatty acid

Table 7. Logistic regression coefficient and odds ratio for the Low cholesterol group compared with normal cholesterol group

Selected variables	Parameter estimate	SE	Odds ratio	p
Energy	−0.0011	0.0024	0.9989	0.6258
Protein	+0.0054	0.0556	1.0054	0.9232
Fat	+0.0868	0.0566	1.0907	0.1249
Sodium	−0.0035	0.0030	0.9965	0.2559
Cholesterol	−0.0009	0.0005	0.9991	0.0832
SFA	−0.2802	0.4494	0.7557	0.5330
MUFA	+0.5142	0.5497	1.6723	0.3495
Tocopherol	−0.0821	0.6696	0.9212	0.9024
Smoking	+0.1746	0.0926	1.1908	0.0593
Drinking	−0.1878	0.1336	0.8288	0.1597
Exercise	+0.0633	0.0598	1.0653	0.2900

SFA : saturated fatty acid
MUFA : monounsaturated fatty acid

rum cholesterol than health related behaviors like drinking and exercise even though the statistical power is rather low.

7. Discussion on the overmatching effect in the selection of controls

This study investigated whether dietary factors would be more influential than other behavioral factors on abnormal serum cholesterol. To better define those effects on serum cholesterol, recognized factors associated with serum cholesterol such as age, obesity and blood pressure had been controlled in the study design by selection of a control group with individual matching. This attempt seems to produce an overmatching effect(Beaglehole et al. 1993) in that there were no variations observed among the three groups in dietary intake as well as health behavior. This result may suggest that sometimes such overmatching in the study design may reduce the difference to a level so low that the particular study design is unable to detect it. This overmatching effect may lead to a false negative conclusion(Beilin 1992) that no difference exists when in fact one does.

It could be quite possible in this study that variables such as age, obesity and blood pressure were in the causal pathway between the study factor(dietary factor) and blood cholesterol. For example, if obesity altered blood pressure which in turn was causally associated with abnormal blood cholesterol, obesity would be considered a cause of abnormal blood cholesterol. Yet in this case control study, once cases and controls were matched on an obesity level then no association of abnormal blood cholesterol with obesity would emerge.

Fortunately, the logistic regression analysis overcomes this overmatching effect and is able to detect the small difference between the normal and abnormal blood cholesterol group as shown in tables 6 and 7 that showed dietary factors such as tocoperol and monounsaturated fatty acid appear to be more influential than health behavior such as smoking and drinking. Nonetheless, other dietary factors such as energy ($p=0.88$), protein($p=0.59$), fat($p=0.31$), sodium($p=0.33$), cholesterol($p=0.36$) still showed no effect on high serum cholesterol. This may imply that even the logistic regression analysis model was not able to overcome the overmatching effect satisfactorily. Therefore, in retrospect, random selection instead of individual matching for the control selection would have been more a effective method in this study.

Conclusion

From the above results, although the Korean dietary pattern is quite different from that of Europeans and Americans ; dietary factors are still significant

risk factors for abnormal blood cholesterol. Therefore, the dietary risk factors identifed by observation of a high fat consuming populations still seem relevant for the relatively healthy Koreans as a guideline for preventive health practices.

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