Lifestyle and the Development of Dyslipidemia: a 4-year Follow-up Study of Middle-aged Japanese Male Office Workers

Noriyuki NAKANISHI^{*1}, Koji NAKAMURA^{*2}, Kenji SUZUKI^{*3} and Kozo TATARA^{*1}

^{*1} Department of Social and Environmental Medicine, Course of Social Medicine, Osaka University Graduate School of Medicine, Osaka

^{*2} Medical Office, Osaka Main Office, Takenaka Corporation, Osaka

^{*3} Japan Labor and Welfare Association, Tokyo

Abstract

To examine the lifestyle factors related to the development of dyslipidemia [low-density lipoprotein (LDL) cholesterol ≥ 150 mg/dL, high-density lipoprotein (HDL) cholesterol < 40 mg/dL, or triglyceride ≥ 250 mg/dL], 979 dyslipidemia-free Japanese male office workers aged 35 to 54 years were followed up for four years. The numbers of new incidence cases during the follow-up period were 216 for high LDL cholesterol level, 109 for low HDL cholesterol level, and 78 for high triglyceride level. From the Cox proportional hazards model, adjusted hazard ratios (HRs) for the incidence of high LDL cholesterol level were 0.62 [95% confidence interval (CI): 0.47-0.82] for consuming alcohol every day, 1.39 (95% CI: 1.10-1.77) for 5-kg/m² increase in body mass index (BMI), 1.45 (95% CI: 1.10-1.91) for snacking between meals every day, and 1.64 (95% CI: 1.18-2.30) for not eating vegetables every day. As for the incidence of low HDL cholesterol level, adjusted HRs for current cigarette smoking, consuming alcohol every day, and 5-kg/m² increase in BMI were 1.74 (95% CI: 1.17-2.59), 0.61 (95% CI: 0.41-0.89), and 1.79 (95% CI: 1.29-2.46), respectively. Adjusted HRs for the incidence of high triglyceride level were 1.73 (95% CI: 1.07-2.77) for current cigarette smoking, 1.74 (95% CI: 1.10-2.77) for 5-kg/m² increase in BMI, and 0.50 (95% CI: 0.27-0.90) for working 10 h per day or more. These results suggest that an increase in BMI, current cigarette smoking, and snacking between meals every day is closely associated with an increased risk of atherogenic lipid profiles. On the other hand, alcohol consumption and eating vegetables every day may have an anti-atherogenic effect on serum lipid profiles.

Key words: lifestyle, incidence of dyslipidemia, follow-up study, Japanese men, middle age

Introduction

The intake of fat and cholesterol and alcohol consumption have increased remarkably with the rapid westernization of lifestyle.¹⁾ According to the National Nutrition Survey, serum total cholesterol levels increased by 13-16 mg/dL for both men and women between 1980 and 1990.²⁾ Recent increases in the levels of serum total cholesterol accompanied by changes in lifestyle warrant concern, and the relationship between lifestyle factors and serum lipid and lipoprotein levels is therefore of considerable interest.

Although effective pharmacological treatments for hyperlipidemia have been developed, long-term use of cholesterol-lowering drugs carries both costs and risks.^{3,4)} As the

majority of the burden of coronary heart disease (CHD) falls on people with only mildly to moderately elevated cholesterol levels, interventions which are economically affordable and widely applicable are needed to maximize the prevention of CHD. Furthermore, a large population could be reached by non-pharmaceutical remedies or lifestyle intervention for risk factors in which the general population may have a greater confidence regarding safety. Therefore, the eventual public health goal should be the primary prevention of lipid disorders and their sequelae.

To promote primary prevention of dyslipidemia at the workplace, the evaluation of lifestyle in the stage of primary prevention is considered important, and the lifestyle factors related to the development of dyslipidemia have to be identified. In this report based on a longitudinal population study using annual health examinations at the workplace, we have tried to identify the lifestyle factors in the chain of causation by estimating the risk of incidence of dyslipidemia among middle-aged Japanese men.

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Reprint requests to: Noriyuki NAKANISHI,

Department of Social and Environmental Medicine, Course of Social Medicine, Osaka University Graduate School of Medicine

2-2 Yamada-oka, Suita-shi, Osaka 565-0871, Japan

TEL: +81(6)879-3911 FAX: +81(6)879-3919

Materials and Methods

Study Cohort

To evaluate the lifestyle factors related to the development of dyslipidemia, a systematic surveillance of the incidence of dyslipidemia was conducted between 1994 and 1998 among employees of T Corporation, which is one of the biggest building contractors in Osaka. All Japanese male office workers aged 35 to 54 years in May 1994 were invited to attend the survey (N=1,368), and the participation rate was 99.9% (N=1,367). During the initial examination, fasting blood samples were drawn from an antecubital vein. Total cholesterol, high-density lipoprotein (HDL) cholesterol, and triglyceride were analyzed with Olympus AU-5000 (Olympus Japan Co, Ltd., Tokyo, Japan) by the Nihon Clinical Laboratories Inc. (Tokyo, Japan). Quality control of the laboratory was maintained internally, and the coefficients of variations were within 3% for total cholesterol, HDL cholesterol, and triglyceride during the entire survey period. Low-density lipoprotein (LDL) cholesterol was calculated with the aid of the formula of Friedewald et al.⁵ Subjects were classified as having dyslipidemia if their level of LDL cholesterol was 150 mg/dL or more, or HDL cholesterol was less than 40 mg/dL, or the triglyceride level was 250 mg/dL or more. The medical history and the history of use of prescribed drugs of the subjects were assessed by the examining physicians. Of the total of 1,367 subjects, 373 (27.3%) were identified to be dyslipidemic at the initial examination. For 15 subjects (1.1%) who had been undergoing medical care for dyslipidemia, the normolipidemic values were recorded. The remaining 979 subjects constituted the study cohort. Subjects who were found to have become dyslipidemic during repeat surveys up to May 1998 were defined as new incidences of dyslipidemia. Thirty-four subjects who were given anti-hyperlipidemic drugs during the observation period were also considered to be new incidence cases. Follow-up until May 1998 could be completed for only 916 subjects (93.6%), because 63 (6.4%) had transferred to another locality or had resigned or retired during the follow-up study. The numbers of incidence cases during the follow-up period were 216 for high LDL cholesterol level, 109 for low HDL cholesterol level, and 78 for high triglyceride level.

Study items

The survey at entry included a questionnaire on lifestyle and a physical examination. Data on lifestyle were obtained by interview. Selected items of lifestyle for this study were as follows: cigarette smoking, alcohol intake, overall obesity, eating breakfast, snacking between meals, considering nutritional balance, eating vegetables, coffee drinking, physical exercise, and hours of work and sleep, including the seven items identified in the studies of Belloc and Breslow⁶ and the two items recommended by Morimoto et al.,⁷ composed of eight items on healthy lifestyle for use in a study in Japan, based on that of Belloc and Breslow. Body mass index (BMI) was used as a measure of overall obesity. Weight and height were measured with the subjects wearing typical indoor clothing but with their shoes off. BMI was calculated as weight/height² (kg/m²) and BMI of 26.0 kg/m² or more was regarded as overweight.

Data on lifestyle, except overall obesity, were treated as categorical variables: cigarette smoking (not smoking cigarettes vs smoking cigarettes currently); alcohol intake (not consuming alcohol every day vs consuming alcohol every day); eating

breakfast (eating breakfast every morning vs not eating breakfast every morning); eating between meals (eating between meals every day vs not eating between meals every day); considering nutritional balance (considering nutritional balance vs not considering nutritional balance); eating vegetables (eating vegetables every day vs not eating vegetables every day); physical exercise (exercising once a week or more vs exercising hardly ever); coffee drinking (not drinking a cup of coffee every day vs drinking a cup of coffee or more every day); hours of work (working less than 10 h per day vs working 10 h per day or more); and hours of sleep (sleeping 7 h per night or more vs sleeping less than 7 h per night).

Analytic procedures

The statistical difference of lifestyle factors of the subjects at enrollment in relation to the four age groups was examined by the chi-square test. The incidence of dyslipidemia was defined in terms of the year in which dyslipidemia was identified during the serial annual health examinations. The Cox proportional hazards models were used to evaluate the univariate and multivariate relations between the characteristics at entry and the development of dyslipidemia. Risk factors for the development of dyslipidemia are dichotomous except age and BMI, and all the categorical variables were coded as 0 for no potential risk factors and 1 for potential risk factors.

Data analysis was performed with the SPSS/PC statistical package (Marija J. Norusis/ SPSS Inc., Chicago, Illinois). All reported p-values are two-tailed and the level of significance is $p < 0.05$.

Results

Table 1 shows the characteristics of dyslipidemia-free subjects at baseline according to age. Alcohol intake, eating breakfast, physical exercise, hours of work, and hours of sleep differed significantly among the four age groups. The proportion of the subjects who drank alcohol every day was the lowest among those aged 35 to 39 years. On the other hand, the percentages of those who did not eat breakfast every morning or slept less than 7 h per night were the highest among those aged 35 to 39 years. The percentages of those who exercised hardly ever or worked 10 h per day or more decreased along with an increase in age. Cigarette smoking, overall obesity, snacking between meals, considering nutritional balance, eating vegetables, and coffee drinking did not differ significantly among the four age groups.

Table 2 shows univariate hazard ratios (HRs) for the incidence of dyslipidemia over 4 years as determined with the Cox proportional hazards model. Cigarette smoking was significantly associated with the incidence of low HDL cholesterol and high triglyceride levels. Alcohol intake had a significantly negative association with the incidence of high LDL cholesterol and low HDL cholesterol levels. BMI was significantly associated with the incidence of high LDL cholesterol, low HDL cholesterol and high triglyceride levels. Snacking between meals and eating vegetables were significantly associated with the incidence of high LDL cholesterol level. Hours of work showed a significantly negative association with the incidence of high triglyceride level, and physical exercise achieved marginal statistical significance ($p < 0.077$). There were no significant associations between the incidence of dyslipidemia

Table 1 Characteristics of dyslipidemia-free subjects at baseline

Item	Age in Years					p value ^a
	35-39 (n=171)	40-44 (n=227)	45-49 (n=348)	50-54 (n=233)	All ages (n=979)	
Cigarette smoking: smoking cigarettes currently	42.7%	48.9%	51.1%	45.9%	47.9%	0.285
Alcohol intake: consuming alcohol every day	55.6%	67.4%	61.8%	70.0%	63.9%	0.013
Overall obesity: 26.0 kg/m ² or more in body mass index	11.1%	12.8%	10.1%	14.6%	12.0%	0.393
Breakfast habits: not eating breakfast every morning	21.1%	12.8%	16.1%	11.2%	15.0%	0.032
Snacking between meals: snacking between meals every day	48.5%	41.9%	41.4%	41.6%	42.8%	0.423
Concern with nutritional balance: not considering nutritional balance	41.5%	41.4%	41.4%	33.9%	39.6%	0.241
Vegetable consumption: not eating vegetables every day	14.6%	18.5%	16.1%	14.2%	15.9%	0.596
Coffee drinking: drinking a cup of coffee or more every day	87.7%	89.9%	83.3%	84.1%	85.8%	0.118
Physical exercise: exercising hardly ever	53.8%	46.3%	46.8%	35.2%	45.1%	0.002
Hours of work: working 10 h per day or more	44.4%	37.4%	22.4%	20.2%	29.2%	<0.001
Hours of sleep: sleeping less than 7 h per night	70.8%	65.6%	59.2%	59.7%	62.8%	0.039

^a Chi-square test.Table 2 Univariate hazard ratios^a for the incidence of dyslipidemia over 4 years

Risk factor ^b	High LDL cholesterol level			Low HDL cholesterol level			High triglyceride level		
	HR	95% CI	p value	HR	95% CI	p value	HR	95% CI	p value
Age (5-year intervals)	1.03	0.91-1.16	0.685	1.10	0.92-1.31	0.310	1.00	0.81-1.23	0.997
Cigarette smoking: smoking cigarettes currently	0.88	0.67-1.15	0.358	1.59	1.08-2.32	0.018	1.67	1.06-2.62	0.027
Alcohol intake: consuming alcohol every day	0.61	0.47-0.80	<0.001	0.63	0.43-0.91	0.015	1.06	0.67-1.70	0.796
Body mass index (5-kg/m ² intervals)	1.45	1.15-1.83	0.002	1.68	1.23-2.29	<0.001	1.37	1.01-1.85	0.045
Breakfast habits: not eating breakfast every morning	1.13	0.79-1.61	0.515	0.83	0.47-1.45	0.511	1.12	0.62-2.03	0.714
Snacking between meals: snacking between meals every day	1.56	1.20-2.04	<0.001	1.37	0.94-2.00	0.098	0.75	0.47-1.18	0.213
Concern with nutritional balance: not considering nutritional balance	0.87	0.66-1.15	0.340	1.36	0.94-1.99	0.106	0.95	0.60-1.49	0.816
Vegetable consumption: not eating vegetables every day	1.50	1.09-2.08	0.013	0.97	0.58-1.63	0.904	1.26	0.71-2.20	0.428
Coffee drinking: drinking a cup of coffee or more every day	0.92	0.63-1.33	0.639	1.34	0.73-2.43	0.344	0.82	0.45-1.48	0.508
Physical exercise: exercising hardly ever	1.03	0.79-1.35	0.824	0.92	0.63-1.34	0.650	1.50	0.96-2.34	0.077
Hours of work: working 10 h per day or more	1.12	0.84-1.49	0.438	1.15	0.77-1.72	0.495	0.52	0.29-0.93	0.028
Hours of sleep: sleeping less than 7 h per night	0.96	0.73-1.26	0.771	1.10	0.74-1.63	0.629	1.12	0.70-1.79	0.624

^a HR indicates unadjusted hazard ratio; CI, confidence interval.^b Risk factors are dichotomous except age and body mass index.Table 3 Multivariate hazard ratios^a for the incidence of dyslipidemia over 4 years

Risk factor ^b	High LDL cholesterol level			Low HDL cholesterol level			High triglyceride level		
	HR	95% CI	p value	HR	95% CI	p value	HR	95% CI	p value
Age (5-year intervals)	1.06	0.93-1.21	0.381	1.13	0.94-1.36	0.204	0.95	0.76-1.18	0.617
Cigarette smoking: smoking cigarettes currently	0.94	0.71-1.24	0.655	1.74	1.17-2.59	0.006	1.73	1.07-2.77	0.024
Alcohol intake: consuming alcohol every day	0.62	0.47-0.82	<0.001	0.61	0.41-0.89	0.011	1.04	0.64-1.67	0.881
Body mass index (5-kg/m ² intervals)	1.39	1.10-1.77	0.007	1.79	1.29-2.46	<0.001	1.74	1.10-2.77	0.019
Breakfast habits: not eating breakfast every morning	1.16	0.80-1.68	0.437	0.78	0.44-1.39	0.403	0.97	0.52-1.78	0.912
Snacking between meals: snacking between meals every day	1.45	1.10-1.91	0.009	1.16	0.79-1.72	0.449	0.74	0.46-1.19	0.216
Concern with nutritional balance: not considering nutritional balance	0.82	0.61-1.09	0.167	1.35	0.92-2.00	0.128	0.88	0.55-1.41	0.585
Vegetable consumption: not eating vegetables every day	1.64	1.18-2.30	0.004	0.91	0.54-1.55	0.729	1.12	0.63-2.00	0.707
Coffee drinking: drinking a cup of coffee or more every day	0.99	0.68-1.44	0.958	1.25	0.68-2.30	0.473	0.78	0.43-1.43	0.425
Physical exercise: exercising hardly ever	0.97	0.74-1.27	0.817	0.90	0.61-1.33	0.611	1.46	0.92-2.31	0.109
Hours of work: working 10 h per day or more	1.21	0.89-1.63	0.223	1.31	0.86-2.00	0.210	0.50	0.27-0.90	0.022
Hours of sleep: sleeping less than 7 h per night	0.81	0.61-1.08	0.156	1.01	0.67-1.53	0.948	1.26	0.78-2.05	0.341

^a HR indicates adjusted hazard ratio; CI, confidence interval.^b Risk factors are dichotomous except age and body mass index.

and age, eating breakfast, considering nutritional balance, coffee drinking and hours of sleep.

Table 3 shows adjusted HRs for the incidence of dyslipidemia in a multivariate model in which factors independently associated with the development of dyslipidemia were identified through mutual adjustment. Factors showing a significant relationship with the incidence of high LDL cholesterol were alcohol intake, BMI, snacking between meals, and eating vegetables. Adjusted HRs were 0.62 [95% confidence interval (CI): 0.47-0.82] for consuming alcohol every day, 1.39 (95% CI: 1.10-1.77) for 5-kg/m² increase in BMI, 1.45 (95% CI:

1.10-1.91) for snacking between meals every day, and 1.64 (95% CI: 1.18-2.30) for not eating vegetables every day. As for low HDL cholesterol level, cigarette smoking, alcohol intake and BMI were independently associated with the incidence of low HDL cholesterol level. Adjusted HRs for cigarette smoking currently, consuming alcohol every day and 5-kg/m² increase in BMI were 1.74 (95% CI: 1.17-2.59), 0.61 (95% CI: 0.41-0.89), and 1.79 (95% CI: 1.29-2.46), respectively. Cigarette smoking, BMI, and hours of work showed significant relationships with the incidence of high triglyceride levels. Adjusted HRs for cigarette smoking currently, 5-kg/m² increase in BMI and working 10 h

per day or more were 1.73 (95% CI: 1.07-2.77), 1.74 (95% CI: 1.10-2.77), and 0.50 (95% CI: 0.27-0.90), respectively.

Discussion

In this report on a longitudinal population study based on annual health examinations at the workplace, we have tried to identify the lifestyle factors related to dyslipidemia by estimating the risk of incidence of dyslipidemia over a 4-year period among middle-aged Japanese men. As reported in numerous previous studies,⁸⁻¹² overall obesity indicated by BMI was found to be an independent risk factor associated with increased levels of LDL cholesterol and triglyceride and reduced levels of HDL cholesterol. In this study, BMI had an independent association with the incidence of each serum lipid and lipoprotein disorder. Obesity has been found to be accompanied by an increased risk of CHD,¹³ but whether obesity is an independent risk factor for CHD is still uncertain, since CHD is mediated mainly through the metabolic consequences of obesity: hypertension, glucose intolerance, and diabetes mellitus as well as serum lipid and lipoprotein disorders.^{8-10, 14-16} However, the fact that weight reduction in obese patients affects these other risk factors makes obesity important in the treatment of dyslipidemia.¹⁷ Although only 12.0% of our participants were deemed overweight (BMI $\geq$ 26.0 kg/m²), obesity should be a major target for CHD prevention in middle-aged Japanese men.

As for smoking, many studies have noted an inverse relationship between smoking and HDL cholesterol levels,^{11, 12, 18-20} which in conjunction with alterations in HDL cholesterol's anti-atherogenic properties is one suggested mechanism whereby smoking increases the risk of coronary arteriosclerosis. The triglyceride level in whole serum and a very low density lipoprotein (VLDL) fraction have been also found to increase with cigarette smoking.¹⁹ Phillips et al.¹⁹ have reported a positive association between the number of cigarettes smoked and beta lipoproteins and posited that this effect is secondary to the higher VLDL triglyceride levels in smokers. In this study, current cigarette smoking was independently associated with the incidence of low HDL cholesterol and high triglyceride levels. In the population surveyed for this study, half of our participants smoked cigarettes. Smoking cessation is one of the most effective factors in health education programs for middle-aged Japanese men to reduce the risk of CHD.

This study showed that daily alcohol consumption had an independently inverse association with the incidence of high LDL cholesterol and low HDL cholesterol levels. These results are consistent with the results of the Cooperative Lipoprotein Phenotyping Study and the Lipid Research Clinics Program Prevalence Study in the USA^{21, 22} and the randomized, controlled crossover trial in Japan.²³ It can therefore be suggested that even in a population characterized by lower serum cholesterol levels like the Japanese, alcohol has an anti-atherogenic effect by altering both LDL and HDL cholesterol. However, large amounts of alcohol intake are associated with higher risk of mortality from hypertension, stroke, cardiomyopathy and cirrhosis.^{24, 25} Thus, a general recommendation cannot be given without reservation.

Favorable effects of regular physical activity on increased levels of HDL cholesterol and reduced levels of triglyceride have been observed.^{12, 17, 26} Nikkila et al.²⁶ have reported that endurance training is associated with an adaptive increase in lipoprotein

lipase (LPL) activity not only in skeletal muscle but also in adipose tissue and that the high HDL cholesterol levels of physically active people are probably accounted for, at least partly, by the increase in LPL activity and the concomitant rapid turnover of triglyceride-rich lipoproteins. In this study, exercising once a week or more had a univariately negative association with the incidence of low HDL cholesterol level, but did not achieve statistical significance. We assume that for our population, physical exercise may be an important preventive modality for subjects with reduced levels of HDL cholesterol, but further investigations should be needed to identify the frequency and strength of regular physical exercise to prevent reduced levels of HDL cholesterol in middle-aged Japanese men.

As for dietary habits, previous studies have linked the consumption of vegetables, fruits, and grain products rich in fibers with the reduction in serum LDL cholesterol.^{27, 28} Furthermore, several studies have shown that the addition of water-soluble fibers, such as guar gum and pectin, to the diet of healthy volunteers resulted in decreases in the level of LDL cholesterol, without any effect on the levels of HDL cholesterol or triglycerides.^{29, 30} This study showed that not eating vegetables every day was an independent risk factor for the incidence of high LDL cholesterol level. Furthermore, snacking between meals was independently related to the incidence of a high LDL cholesterol level. These results suggest that poor dietary habits have an atherogenic effects by altering serum lipid and lipoprotein profiles.

We found that hours of work had an independently negative association with the incidence of high triglyceride level. From the nutritional survey in this population, there were significant differences ($p < 0.001$, Student's *t*-test) among the consumed energy values for the two subgroups with regard to hours of work [$2,419 \pm 291$ kcal/day for working less than 10h/day and $2,597 \pm 271$ kcal/day for working 10h/day or more (mean $\pm$ SD)]. The negative association between triglyceride level and hours of work might be derived from the high consumption of energy related to working long hours. As for the effect of long work hours on health, working long hours has been shown to be related to coronary heart disease, stress, mental health indefinite complaints, fatigue, dissatisfaction with work, and depression.³¹⁻³⁹ In this population, the number of working hours showed a close association with adaptive and maladaptive lifestyle factors, and the percentages of those who had BMI of less than 26.0 kg/m², exercised hardly ever, or slept less than 7 h per night were significantly higher among those who worked 10h per day or more than among those who worked less than 10 h per day (91.3% vs 86.7%, $p = 0.047$; 50.3% vs 43.0%, $p = 0.036$; and 77.6% vs 56.7%, $p < 0.001$, respectively). Further research is needed to clarify whether working long hours contributes to or is responsible for health conditions, including serum lipid and lipoprotein.

Several studies^{40, 41} have reported that consumption of unfiltered, boiled coffee is closely associated with raised serum cholesterol levels. The diterpenes cafestol and kahweol (non-triglyceride lipids present in coffee) are shown to be responsible for the hypercholesterolemic effects of boiled coffee.⁴² As for the triglyceride level, investigations into the effects of coffee consumption on triglycerides have variously found that it is either positively related⁴³ or negatively related¹⁹ to increased level of triglyceride. In this study, there was no significant association between coffee consumption and the incidence of high LDL

cholesterol and triglyceride levels. Further investigation is needed to identify whether coffee consumed in Japan, which is mostly instant or filtered, might be a risk factor for the incidence of dyslipidemia in middle-aged Japanese men.

This study has several limitations. First, identification of incidental cases of dyslipidemia is a problem in conducting longitudinal studies of this common condition. Variability of serum lipid and lipoprotein levels makes it difficult to establish both normolipidemia at baseline and subsequent incidence of dyslipidemia in epidemiological studies in which investigators rely on a limited number of measurements of serum lipid and lipoprotein.

The second problem concerns the cases which could not be followed up until the end of observation. In this study, the follow-up rate until the end of this survey was 93.6%, and non-followed up cases did not differ from followed up cases with respect to age and lifestyle at entry. We therefore believe that the influence of non-followed up cases on estimations of the incidence of hyperlipidemia was not very strong.

The third is that the dyslipidemia-free cohort in this study, particularly in older age groups, may not be typical of the general population. Individuals whose serum lipid and lipoprotein levels

were already dyslipidemic when they were younger or who reported having been administered medical treatment for hyperlipidemia during the initial examination were excluded from this survey. Thus, a healthy worker effect may exist in this study.

Despite these potential limitations, our findings, obtained from a cohort of middle-aged Japanese men, support the conclusion that an increase in BMI, current cigarette smoking, and snacking between meals every day are closely associated with an increased risk of atherogenic lipid profiles. On the other hand, alcohol consumption and eating vegetables every day may have an anti-atherogenic effect by altering serum lipid profiles.

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